PACNAVFACENGCOM METRIC PROGRAM

METRIC GUIDE FOR CONTRACT DOCUMENT PREPARATION

SEPTEMBER 2001

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* Not included

PACNAVFACENGCOM METRIC PROGRAM
GUIDE FOR CONTRACT DOCUMENTS PREPARATION

I. GENERAL INFORMATION

A. PACDIV METRIC PROGRAM

The metric program goal is to fully implement metric in planning, design, and construction.

The PACNAVFACENGCOM metric program provides design procedures in preparing uniform contract documents, stimulate metric awareness and understanding by design and construction personnel and activities, and simplify A-E design coordination and guidance.

B. BACKGROUND INFORMATION

Metric implementation was mandated by Executive Order 12770 of July 25, 1992 as the preferred system of weights and measures for United States trade and commerce. See Appendix C, Section C - 1, on Metric Usage in Federal Government Programs.

C. NAVFAC POLICIES

NAVFAC policy mandated that projects be designed in metric beginning October 1996. Verify with the DPM 04 Project Design Engineer (PDE) and DPM 03 Project Managers (PM) on metric requirements for other Government agencies such as the Air Force, DLA, etc.

D. PACDIV POLICY

1. Metric Guidance

Comply to the PACDIV A-E Metric Guide for Contract Document Preparation. Policy priorities on metric usage are (1) PACDIV, (2) NAVFAC, (3) AIA, and (4) GSA.

2. Project Documents

PACDIV policy requires all project documents be designed in metric unless directed otherwise by PDE or Branch Managers. Every effort must be made to design projects in metric. Projects should be in metric unless affected by compressed design schedule or complex additions or renovations.

Project Types	One Story	Two or More Stories
New Projects	Metric	Metric
Additions	Metric	Metric or IP
Renovations	Metric or IP	Metric or IP

II. DESIGN DOCUMENTS PREPARATION

A. REFERENCES

The following references are priorities in descending order to prepare contract documents in metric in addition to the PACDIV metric guidelines:

1. NAVFAC Metrication Conversion Policy for Design, Planning and Design Criteria, and NAVFAC Guide Specifications, January 1995.

2. A.I.A. Mastermetric, A Guide for Using The International System (SI) in Construction Documents

3. GSA Region 3's M2 Publication

B. TERMINOLOGY/DEFINITIONS

Construction, manufacturers' products, existing conditions, and building codes will greatly impact preparation of design documents in metric. Because the metrication process of the building industry in the United States is anticipated to extend over a period of ten years, alternative methods of design in metric must be established. Alternative methods and terminology such as "hard metric", "soft metric", "nominal metric", and other designations in preparing design documents must be established, used, and understood. The International System of Metric (SI) will be referred to as "metric".

1. HARD METRIC

A hard metric measurement indicates a non-interchangeable SI value. It is based on SI values which involves change in size and properties from I-P (inch pound) values. Hard metric measurements are often used for field data and building dimensions. Products are considered hard metric when manufactured to SI metric dimensions or have an industry recognized metric designation. It means most products will require physical change to conform to the 600 mm by 600 mm metric design planning grid.

2. SOFT METRIC

A soft metric measurement is a mathematical approximation or an equal unit conversion of an I-P (inch pound) product. Soft metric measurement will allow use of current products in I-P units without physically modifying the products. For example, a soft metric conversion of 2 inches is 50.8 mm. Linear Metric Conversion Table, Appendix A, Section A - 2, provides soft metric units which are equal or less than the I-P units. However, soft metric dimensions must comply to maximum or minimum requirements of design and life safety codes.

3. NOMINAL METRIC

Nominal metric units are alternate and convenient designations for products with nominal I-P units established as industry standards. For example, a nominal 2 inch pipe with an actual outside diameter of 2.375 inches becomes a nominal 50 mm metric pipe. The nominal metric unit is derived from a rounded conversion of the nominal 2 inch, not from the actual 2.375 inches. On the other hand, 38 x 89 mm is the current nominal designation by the lumber industry for a nominal 2 x 4 wood stud. The actual dimensions 1 ½" x 3 ½" of the 2 x 4 is also 38 x 89 mm. However, current 38 x 89 mm for the nominal 2 x 4 IP may be eventually renamed to 50 x 100.

C. DRAWINGS

1. GENERAL REQUIREMENTS

a. Sheet Size

(1) Metric size sheets will be the International Organization for Standardization (ISO) A1 size of 594 x 841 mm (23.4 x 33.1 inches). See Appendix A, Section A-6, for metric sheet and title/revision blocks.

(2) Drawings may be printed on 24 x 36 inch "D" size standard sheets until the metric A1 sheets becomes available at the printing companies and the Navy Printing Services. However, drawing margins and title blocks will be in metric as shown on Appendix A.

b. Metric Writing Guidelines

(1) Metric Unit Acronyms/Symbols - See Appendix A, Section A - 1, Design and Construction Metric Units.

(2) Design and Construction - See Appendix A, Section A - 5, Basic Writing Guidelines of acronyms, unit names, and numbers.

c. Letter Size

Drawing notes	3 mm (1/8")	CADD generated
	4 mm (5/32")	hand drawn
Drawing titles	6 mm (1/4")	

d. Metric Design Scale

Preferred design scales are:

SI Scale	SI Unit Equivalent	IP Ratio	IP Scale Equivalent
* 1:1	300 mm = 300 mm	1:1	Full size 12"=1'-0"
* 1:5	60 mm = 300 mm	1:4	Close to 3" = 1'-0"
* 1:10	30 mm = 300 mm	1:8	Close to 1 1/2"= 1'-0"
* 1:20	15 mm = 300 mm	1:20	Close to 5/8" = 1'-0"
1:25	12 mm = 300 mm	1:24	Close to 1/2" = 1'-0"
* 1:50	6 mm = 300 mm	1:48	Close to 1/4" = 1'-0"
* 1:100	3 mm = 300 mm	1:96	Close to 1/8" = 1'-0"
* 1:200	meter	1:192	Close to 1/16" = 1"-0"
1:250	meter/kilometer	1:240	Close to 1" = 20'-0"
* 1:300	kilometer	1:300	Close to 1"= 25'-0"
* 1:500	kilometer	1:480	Close to 1" = 40'-0"
* 1:1000	kilometer	1:960	Close to 1" = 80'-0"
1:2500	kilometer	1:2400	Close to 1" = 200'-0"

* Metric scale recommended by NAVFAC.

Metric Ratios from 1:1 to 1:100 are based on a metric scale length of 300 millimeters. As an example, 1:50 equates to 1/50 ratio of scale length of 300 mm. 1/50 of 300 mm equals to 6 mm which is close to 1/4".

e. Metric Graphic Scales

Metric graphic scales are mandatory on the drawings. It will provide visual verification of dimensions during design of the project, review of reduced size drawings of design submittals, or reproduction of microfilmed copies of drawings. See metric graphic scales in Appendix A, Section A–7.

f. Drawing Reference Symbol

Reference symbols shall be 20 mm diameter where sections or elevations are taken or details are referred to, and 25 mm diameter for drawing titles. See Appendix A, Section A - 7 for reference symbols.

2. LINEAR METRIC DESIGN UNITS

a. Design Applications

(1) Hard Metric Units

Hard metric units will be used for linear dimensions to locate and indicate size of walls, equipment, etc. on plans, establish heights, and for products available in metric.

(2) Soft Metric Units

Soft metric units in Appendix A, Section A - 2, Linear Metric Unit Conversion Table, will be used for non-metric materials and products.

Use soft metric designating existing conditions. Dimension the total wall thickness instead of dimensioning each material thickness.

(3) Nominal Metric Units

Nominal metric units will indicate nominal U.S Customary unit product sizes and thickness and metric nominal units established by the material and product manufacturers.

b. Rounding Metric Units

Round units to simplify design and construction. Linear Metric Rounding Guidelines For Design and Construction, Appendix A, Section A-4, provides preferred rounded metric units for non-metric products and materials.

c. Decimals

Do not use decimals when designing with the millimeter scale except for products or materials such as sheet metal, finishes, etc. For meters, use not more than three decimal digits. Appendix A, Section A-5, Basic Metric Writing Guidelines, provides guidance on decimals.

d. Drawing Units

(1) Use millimeters for building construction drawings for metric scales 1:5 to 1:200. Omit unit symbol mm for millimeters and add general note to drawings "all dimensions are in millimeters unless otherwise noted".

(2) Dimensions within 5 feet line (1500 mm) from the building perimeter will be in millimeters. Dimensions beyond the 5 feet line (1.5 m) will be in millimeters or meters.

(3) Use kilometer and meter for long distances, metric scales exceeding 1:200, and survey measurement. Use meter and millimeter for site drawings.

(4) Do not use centimeters in preparing contract documents.

(5) Use of any I-P units or combination of I-P units and SI units on the contract documents are not allowed on metric products.

3. OTHER UNIT DESIGNATIONS

a. Existing Conditions

Addition or renovation type projects require installing new materials to existing materials. If the designer is unable to develop a creative design solution at the point of transition between the existing to new, indicate a plus or minus with the dimension and add a notation "match existing". Design solutions may include putting the new walls at right angles, off-setting the new wall, or articulating the wall thickness at the transition point.

b. Refer to Appendix B: PACDIV Design Branch Metric Parameters for specific metric requirements on Architectural, Structural, Mechanical, Electrical, Civil, Specifications/Cost, and Fire Protection contract document preparation.

4. DRAWING SCALE

a. Plans

(1) Site Plans

Civil facility site plans: 1:250 (1" = 20'-0") min.
Architectural site plans: 1:250 (1" = 20'-0") min.
Area/regional plans - Convert meters to kilometers when appropriate

(2) Building Plans

Floor, roof, and ceiling plans: 1:100 (1/8 = 1'-0") min.

(3) Detail Plans

Floor, roof, and ceiling plans : 1:50 (1/4" = 1'-0") min.

b. Elevations

(1) Building Elevations

Exterior and interior elevations: 1:100 (1/8" = 1'-0") min.
1:50 (1/4" = 1'-0") pref.

(2) Detailed Elevations

Exterior and interior elevations: 1:25 (1/2" = 1'-0") min.

c. Sections

(1) Building Sections

Longitudinal and transverse sections: 1:50 (1/4"=1' - 0") min.

(2) Detailed Sections

Wall, floor, and roof sections: 1:25 (1/2" = 1'-0") min.
Interior finish, cabinets, and equipment: 1:25 (1/2"=1'-0") min.

d. Details

(1) Building Details

Floor, wall, and roof : 1:25 (1/2" = 1'-0") min.
Doors, windows, and cabinets: 1:10 (1 1/2" = 1'-0") min.

(2) Miscellaneous: 1:25 (1/2" = 1'-0") min.

D. SPECIFICATIONS

The Unified Facilities Guide specifications (UFGS) include SI and IP units**.** For specification conversion policy, refer to paragraph II.A.1 "NAVFAC Metrication Policy for Design, Criteria, and NAVFAC Guide Specifications, January 1995" and II.A.2 "AIA Master Metric, A Guide For Using The International System (SI) In Construction Documents".

Specification Writers must coordinate with designers on metric terminology, unit designations, converting and rounding, materials less than one millimeter, etc. to minimize conflicts and design errors.

Use non-metric page sizes for specifications.

E. COST ESTIMATES

Cost estimates will be prepared completely in metric.

F. DESIGN ANALYSIS

Design analysis text and calculations will be prepared in metric except when complying to IP codes or where computer software is not available in metric. Prepare the analysis in IP units and convert the results to metric.

G. OTHER DOCUMENTS

1. Value Engineering

   Value Engineering documents shall be in metric. Value Engineering Teams Studies (VETS) and Value Engineering Change Proposals (VECP) shall not override the use of metric in the project design documents.

2. FACD, PEP (Parametric Estimating and Programming), reports, minutes, and other documents shall be prepared in metric.

   During the FACD (Functional Analysis Concept Development) process for projects, the FACD team must present the proposed design concept in SI and IP units. This will enable the user and the activity to better understand sizes, scale, and space requirements of the project in metric terms.

3. Collateral Equipment

   Soft metric units will be used when metric dimensions are not available for collateral equipment. Soft metric dimensions shall be equal or larger than the IP units to allow for adequate space for the collateral equipment when indicating furniture space or layout on drawings.

4. Contractor submittals such as shop drawings, manufacturer material and equipment data, and Operation and Maintenance Manuals shall be prepared in metric. Review comments will be in metric.

5. As-built drawings shall be completed in metric.

H. PACDIV DESIGN BRANCH METRIC PARAMETERS

For specific discipline design guidance on metric units, material, product**,** and equipment, see Appendix B.

III. METRIC INFORMATION SOURCES

A. METRIC ASSOCIATIONS/AGENCIES

1. National Institute of Buildings Sciences (NIBS) (202) 289-7800
   1090 Vermont Avenue, N.W, Suite 700 (202) 289-1092 FAX
   Washington, D.C. 2005-4905 www.nibs.org

2. U.S. Metric Association (USMA) (818) 368-7443
   10245 Andosal Avenue
   Northridge, CA 91325-1504

B. METRIC DESIGN

See Appendix C: Design References And Resources.

C. TRAINING

Contact professional and metric organizations for training information on metric rules, usage, applications, information, etc. Training information is available in video cassettes, training seminars, etc.

D. MANUFACTURERS' MATERIALS AND EQUIPMENT

1. NAVFAC Product Starter List:

   The NAVFAC Product Start List includes 17 base manufacturer's products available in metric. The products include CMU, brick, carpet, steel plate, structural bolts, plywood, metal and wood doors, ceiling systems, elevators, and lighting fixtures. NAVFAC Product Starter List is provided in Appendix D - 1.

2. Canadian Directory of Metric Construction Products

   The directory includes information on manufacturer's associations, construction associations, Canadian metric construction practice guides and design manuals, and Canadian Trade Officers in the United States responsible for building materials.

3. Metric Vendor List

. Metric Vendor List is available from the U.S. Metric Association.

4. Product Resource File

   Develop a metric product resource file. The product resource may be information received from manufacturers, trade or manufacturer associations, or professional organizations, etc.

5. North American Free Trade Agreement (NAFTA) Products

   Develop a resource file for Canadian and Mexican metric products. The North American Free Trade Agreement (NAFTA) of 1993 allows purchase of Canadian and Mexican metric products as domestic construction materials under the Buy American Act for project costs exceeding a certain threshold. FAR 25.405(b) increased the NAFTA threshold amount to $7,068,419.

E. OTHER SOURCES

1. PACDIV Design Branch Managers

   Metric design decisions on projects will be established by the PACDIV Design Branch Managers in response to questions and suggestions on engineering systems, architectural, structural, mechanical, electrical, civil, and fire protection.

2. Cost Estimating

   Cost estimating data information (Means and Richardson) and guidance are available in metric.

IV. APPENDIX A: METRIC GUIDE SUPPLEMENTS

DESIGN AND CONSTRUCTION METRIC UNITS

1. SI BASE UNITS

Six basic units of measurement are used in design and construction.

Design Measurements	Basic SI Units	SI Symbols
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
temperature	kelvin *	K *
	Celsius	C
luminous intensity	candela	cd

* The Celsius scale with symbol C is the everyday scale used most commonly.

2. SI DERIVED UNITS COMMONLY USED IN ENGINEERING

Design Items	IP Units	SI Units	SI Symbols
angle	radians	radians	rad
	degrees	degrees	deg
area	square inch	square centimeter	cm^2
	square foot	square meter	m^2
	acre	hectare	ha
	square mile	square kilometer	km^2
		hectare	ha
density	pound/cu ft	kilogram/cu meter (Avoirdupois)	kg/m^3
electric: current	ampere	ampere	A
potential	volt	volt	V
energy	Btu	joule	J

Design Items	IP Units	SI Units	SI Symbols
flow	cubic feet/sec	cubic meter/sec	m^3/s
force	ounce pound kip ton	newton newton kilonewton kilonewton	N N kN kN
heat	BTUH	watt	W
linear measure	inch foot miles	millimeter millimeter meter kilometer	mm mm m km
liquid measure (volume)	ounce gallon	milliliter liter	mL L
luminous intensity	lumen foot candles foot-lambert	candela lux candela/sq meter	cd lx cd/m^2
mass: avoirdupois	ounce pound ton	gram kilogram metric ton	g kg metric ton
moment/torque	foot-kip foot pounds	kilonewton -meter newton-meter	kN-m N-m
pressure (stress units)	pound/square inch kip/square foot kip/square inch pound/square foot	kilopascal kilopascal megapascal pascal	kPa kPa MPa Pa

Design Items		IP Units	SI Units	SI Symbols
power		horsepower	watt kilowatt megawatt	W kW MW
slope		percent numerical ratio (vertical to horizontal)	percent numerical ratio (vertical to horizontal)	% mm : m mm : mm m : m
temperature		Fahrenheit	Celsius	C
thickness:	metal coating	gage inches mils	millimeter millimeter micron	mm mm u (or micron)
time		second hour	second hour	s h
velocity		mile/hour feet/second feet/minute	kilometer/hour meter/second meter/second	km/hr ms ms
volume (dry)		cubic feet cubic yard	cubic meter cubic meter	m^3 m^3

LINEAR METRIC UNIT CONVERSION TABLE					
Inch	Soft Metric (mm)	Rounded Metric (mm)	Feet	Soft Metric (mm)	Rounded Metric (mm)
1/8	3.18	3	1	304.80	304
1/4	6.36	6	2	609.61	609
3/8	9.54	9	3	914.40	914
1/2	12.72	12	4	1219.20	1219
5/8	15.90	15	5	1524.02	1524
3/4	19.07	19	6	1828.80	1828
7/8	22.44	22	7	2133.60	2133
			8	2438.43	2438
			9	2743.20	2743
1	25.40	25	10	3048.00	3048
2	50.80	50	20	6096.07	6096
3	76.20	76	30	9144.10	9144
4	101.50	101	40	12 192.10	12 192
5	127.01	127	50	15 240.20	15 240
6	152.40	152	60	18 288.20	18 288
7	177.70	177	70	21 336.21	21 336
8	203.30	203	80	24 384.30	24 384
9	228.60	228	90	27 432.33	27 432
10	254.00	254			
11	279.41	279	100	30 480.37	30 480
12	304.80	304	200	60 960.74	60 960
			300	91 441.11	91 441
			400	121 921.48	121 921
			500	152 401.85	152.401
			600	182 882.22	182 882
			700	213 362.59	213 362
			800	243 842.97	243 842
			900	274 323.34	274 323
			1000	304 803.71	304 803

METRIC CONVERSION FACTORS
FOR DESIGN AND CONSTRUCTION

A. METRIC DRAWING UNITS

Millimeter (mm)	*Centimeter (cm)	Meter (m)	Kilometer (km)
mm = $\frac{1\ m}{1000}$ 1 mm = .001 m 1000 mm = 1 m	cm = $\frac{1\ m}{100}$ 1 cm = .01 m 100 cm = 1 m	m = 1	km = 1 m x 1000 1 km = 1000 m 0.001 km = 1 m

* Use of centimeters in preparing contract documents is not allowed.

B. LINEAR CONVERSION FACTORS (LCF)

1. SI to IP Units

SI	x	LCF	=	IP
1 mm		0.039 37		in
1 m		3.280 84		ft
1 km		0.621 371		mile

2. IP to SI Units (exact values)

IP	x	LCF	=	SI
1 in		25.4		mm
1 ft		304.8		mm
1 mile		1.609 344		km

C. DESIGN RENOVATIONS

Conversion to linear metric dimensions is required for existing conditions, non-metric materials and equipment, and compliance to code. Three steps required for conversion are (1) analyze project requirement, (2) determine linear dimensions for existing conditions and (3) use appropriate metric scale for drawing the linear dimension.

1. Analyze Project Requirement

   Analyze project requirements for design and life safety codes, and verify availability of metric or non-metric products.

2. Determine Linear Dimension For Existing Conditions

   Prepare contract documents in "hard metric" with minimum use of "soft metric" to match existing dimensions and conditions. Determine minimum or maximum design dimensions and sizes to comply with code requirements. Change IP (feet and inches) to inches, before converting and rounding to SI units. Refer to Appendix B: PACDIV Design Branch Metric Parameters for conversion factors.

3. Use Appropriate Metric Design Scale

   Use the appropriate metric scale (para II.C.4) for plans, elevations, sections, and details.

D. OTHER METRIC UNITS CONVERSION FACTORS

1. Metric Design Units

   Other metric conversion factors associated with specific design requirements for architectural, civil, electrical, mechanical, structural, and fire protection are listed in ASTM E 621, Appendices and Metric Guide for Federal Construction (NIBS).

2. Material and Products

   Refer to A.I.A. Mastermetric, Appendix C - Tables on coatings, wire gages, screw sizes, lumber sizes, pipe and tube designations, and metal and plastic conduit sizes.

LINEAR METRIC ROUNDING GUIDELINES
FOR DESIGN AND CONSTRUCTION

A. DESIGN UNITS

1. In rounding metric units for design, drawing dimensions and detailing, the designer must base their professional assessment and determination on compliance to design and life safety code requirements, government policies, functional scope requirements, physical size limitations, existing conditions, and building products and equipment. See "Para B.1, Design Dimensions" below for preferred minimum rounding units.

2. For design and life safety code requirements, round metric units to comply to maximum or minimum IP units.

3. For building addition to existing conditions, round metric dimensions and add a note “match existing” to the units.

4. For materials and products not available in metric, round soft metric units less than the materials and products unless minimum sizes are required.

B. DESIGN DRAWINGS

1. Design Scale And Preferred Rounding Units

Metric Scale	(IP Scale)	Preferred Minimum Rounding Units		
		Millimeters	Meters	Kilometers
1:1	(full scale)	5 mm	-	-
*1:5	(3"=1'-0")	5 mm	-	-
* 1:10	(1 1/2=1"-0")	5 mm	-	-
* 1:20	(5/8"=1'-0")	5 mm	-	-
1:25	(1/2"=1'-0")	5 mm	-	-
* 1:50	(1/4"=1'-0")	10 mm	-	-
* 1:100	(1/8"=1'-0")	25 mm	-	-
* 1:200	(1/16"=1'-0")	25 mm	0.000 m	-
1:250	(1"=20'-0")	-	0.000 m	0.000 km
* 1:300	(1"=25'-0")	-	-	0.000 km
* 1:500	(1"=40'-0")	-	-	0.000 km
* 1:1000	(1"=80'-0")	-	-	0.000 km

- Metric scale recommended by NAVFAC

2. Preferred minimum rounding will simplify use of metric, design, and construction of the project. As an example, the smallest metric unit dimension is preferred to be 5 mm when using metric scales 1:1 to 1:25 for details and detailed sections because any dimension less than 5 mm may be difficult to draw and construct. Any dimension, material, or product less than the preferred minimum rounding unit of 5 mm (less than 1/4") should be identified as a notation as "3 mm glass", "3 x 3 mm grooves", or "1.5 mm sheet metal" rather than trying to dimension the drawing. For meters and kilometers, the preferred rounding of units is three decimal places (i.e. 0.000).

C. SPECIFICATIONS

The Unified Facilities Guide Specifications (UFGS) are in SI units. The SI units in the specifications must be the same as the SI units in the drawings.

D. COST ESTIMATING

1. For linear measurements, use millimeter and meter for design and construction, kilometer for long distances, and meter and kilometer for survey.

2. For building area computations, the preferred scale is square meters. Use square kilometers for areas larger than the building site. Use meters for building and surrounding site. For very large land areas, use hectare (ha).

3. Cubic meter is preferred for volume (dry) in construction.

4. Appendix B: PACDIV Design Branch Metric Parameters, provides other metric cost estimating rounding information.

E. DESIGN CALCULATIONS

Refer to Appendix B: PACDIV Design Branch Metric Parameters for conversion and rounding guidance on design calculations for architectural, structural, mechanical, electrical, civil, and fire protection.

BASIC METRIC WRITING GUIDELINES
FOR DESIGN AND CONSTRUCTION

This appendix section includes general guidelines for Unit Symbols, Unit Names, and Numbers. Unit Symbols are abbreviations of the unit names used primarily on drawings, specifications, and calculations. Unit names such as millimeters, meters, Celsius are used on written documents as correspondence and reports.

A. Unit Symbols

1. Capital Letter Symbols

Symbol	Metric Units	Design Items
A	ampere	electric current
C	Celsius	temperature
F	farad	capacitance
G	giga	unit (billion) 10^9 (1 000 000 000)
H	Henry	inductance
J	Joule	British thermal unit
K	Kelvin	temperature
L	Liter	liquid
M	mega	unit (million) 10^6 (1 000 000)
N	Newton	force
Pa	Pascal	pressure
T	tera	unit (trillion) 10^{12} (1 000 000 000 000**)**
V	volt	electric voltage
W	watt	heat

- Use capital "L" for liter as not to confuse lower case "l" from the number "1".
- Use capital "M" (mega) for magnitudes 10^6 and higher ("M", "G" and "T").
- Use only one prefix with unit.
- Kelvin is the official SI symbol for temperature, however, Celsius is the most commonly used.

2. Combining symbols of unit name and unit quantity (prefixes)

- Do not leave space between name and quantity. Write "kg", not "k g".
- Do not mix unit names and symbols. Write "Nm", not "N meter".

3. Combining numerical units and unit symbols

   - Provide space between numerical units and unit symbols. Write "45 kg" and not "45kg".
   - Unit symbols (name and quantity) are both singular and plural. Do not add "s" to the end of a symbol to indicate more than one unit. Write "45 kg" and not "45 kgs".

4. Exponents and unit symbols

   - For numerical quantity, do not provide space between the unit symbol and the exponent (power). Write "m^3", not "$m\ ^3$". Use decimals prefixes for magnitudes of 10^3 and less, and numerical exponent (power) less than 10^6.
   - For temperature, provide a space between the numerical temperature unit (10) and the degree (^{0}) as an example of 10 ^{0}C. Combine "^{0}" as prefix to "C". Write "^{0}C", not "^{0} C" or "C^0". The symbol of Kelvin is given as a K, without the degree symbol.

5. Plurality

   - Symbols are used as singular or plural. Do not add "s" to symbols to indicate plural. Symbols never change to plural by adding “s” to the unit symbol.

6. Unit Prefixes and Symbols

   Unit prefixes are attached to unit symbols to form multiple units. As an example, symbol 1 km is 1000 m or “k” prefix symbol attached to a “ m” unit symbol to form a multiple symbol. Kilogram (kg) is the only SI unit with a prefix as part of its name and symbol. Do not use multiple prefixes with a unit and kilogram (kg).

SI Unit Symbol Prefixes (of meter)		
Symbol	Prefix	Unit Factor
T	tera	10^{12} 1 000 000 000 000
G	giga	10^{9} 1 000 000 000
M	mega	10^{6} 1 000 000
k	kilo	10^{3} 1000
h	hecto	10^{2} 100
da	deka	10^{1} 10
d	deci	10^{-1} 0.1
c	centi	10^{-2} 0.01
m	milli	10^{-3} 0.001
u	micro	10^{-6} 0.000 001
n	nano	10^{-9} 0.000 000 001
p	pico	10^{-12} 0.000 000 000 001

B. Unit Names

1. Spell names in lower case including those derived from names except for Celsius. (eg: meter, millimeter, kilogram, second, newton, pascal, liter)

2. Combining units and quantities

   Do not mix unit names and symbols. Write "newton meter", not "N meter".

3. Plurality

   In writing, add "s" to end of unit names to indicate a value greater than one except for hertz, lux, and siemens. The word “metric” is used as singular and plural.

4. Exponents and unit names

   Exponents could be expressed as numerical powers with unit symbols or written as "square", "squared", "cubic", and "cubed" with unit names. Write exponents preceding the unit names as "square meters" for area and "cubic meters" for volume, etc. Write exponents following the unit names as "meters squared" and "meters cubed".

   For written documents such as letters, reports, etc., abbreviations of exponents as "sq." (square or squared) and "cu" (cube or cubed) should not be used with written unit names (eg: not sq. millimeter, cu. meter, sq. mm, m^2 , mm^3).

   For drawings and specifications, use symbols for unit names and exponents.

C. Numbers

1. Numerical Arrangement

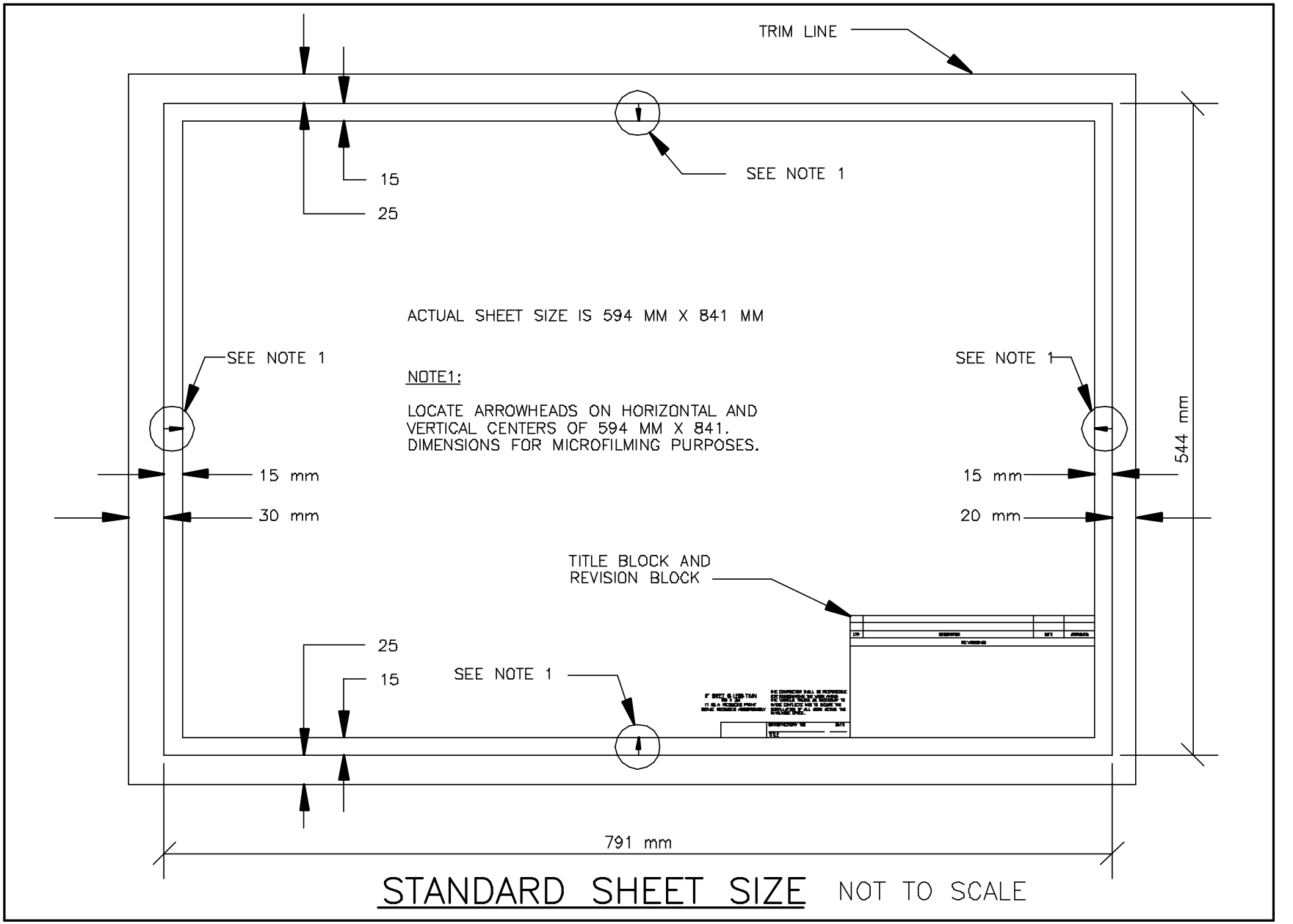
Number of Digits	Arrangement	Example
0 digits or less	Group to right of decimal (millimeter)	0.1
0 digits or less	Group to right of decimal (meter)	0.123
3 digits	Group three digits together	321
4 digits or less	Group four digits together	4321
5 digits or more	Group digits in threes with space	654 321

2. Decimal Point

   - Do not use decimal point for millimeters except for materials and products manufactured less than one millimeter in thickness such as sheet metal.
   - Use decimals for meter units. Use not more than three digits (thousand unit = millimeters) to the right of the decimal point when using meters. Place a zero to the left of the decimal point for units less than 1.
   - Provide a space between numerical groupings instead of commas.

3. Other Metric Numerical Units

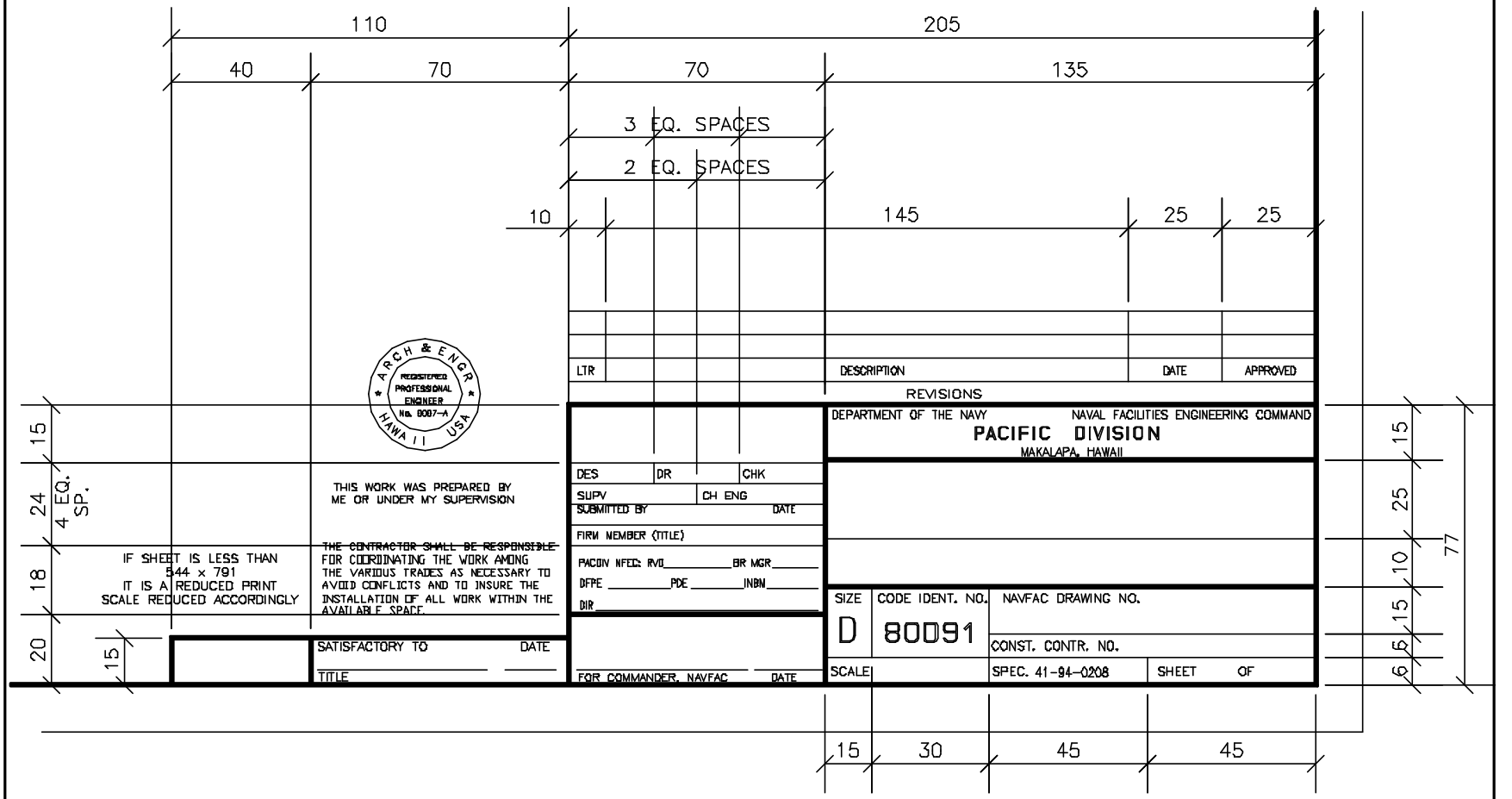
   - Use microns for coating and film thickness. 1 mil = 0.0254 mm = 25 microns. See conversion table on page B-6.e.



STANDARD SHEET SIZE NOT TO SCALE

NOTE:

ALL DIMENSION VALUES ARE IN MILLIMETERS (mm).

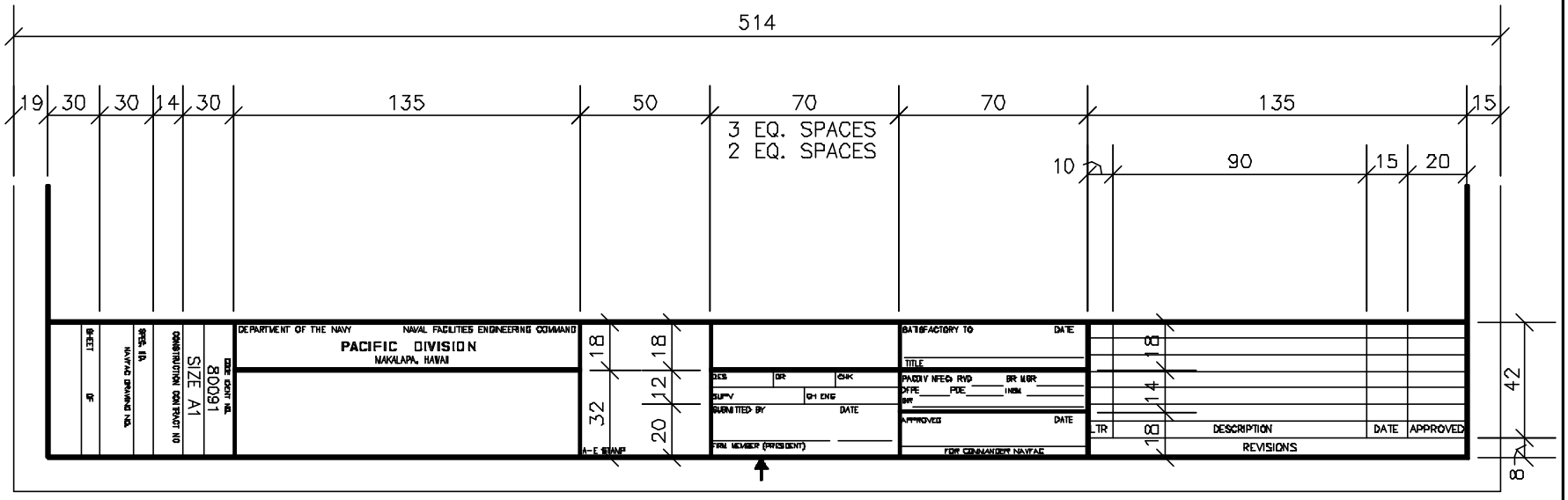


A-E TITLE/REVISION BLOCK

NOT TO SCALE

NOTE:

ALL DIMENSION VALUES ARE IN MILLIMETERS (mm).



A–E TITLE/REVISION BLOCK

NOT TO SCALE

NOTE:

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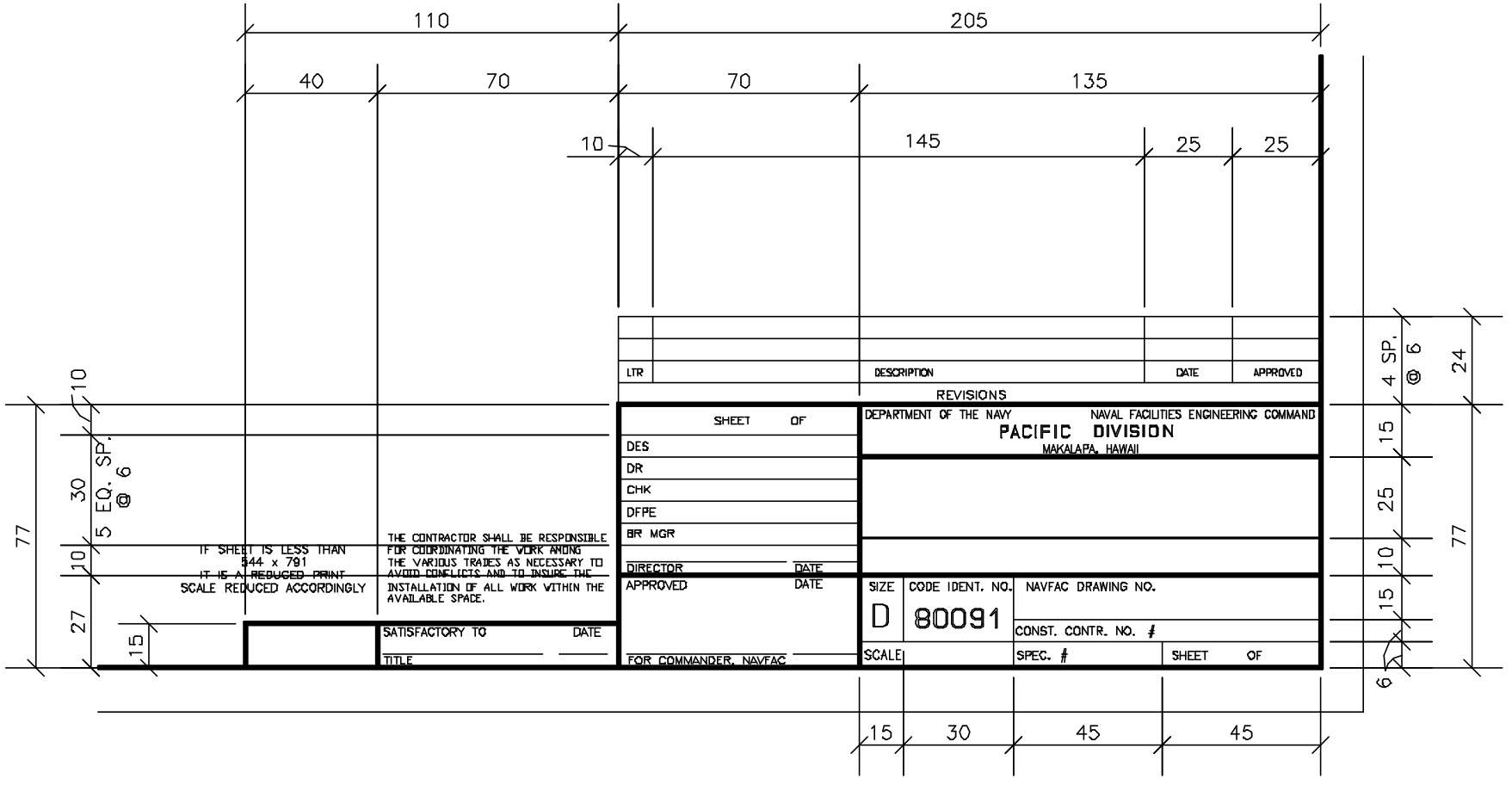


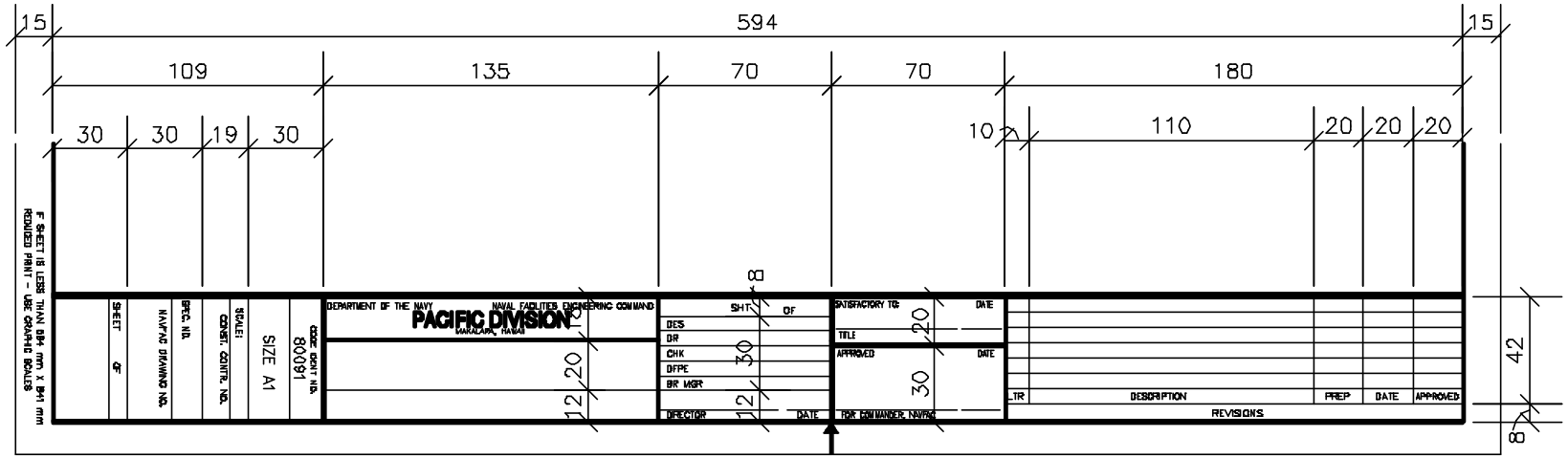
IN-HOUSE TITLE/REVISION BLOCK

NOT TO SCALE

A-6.d

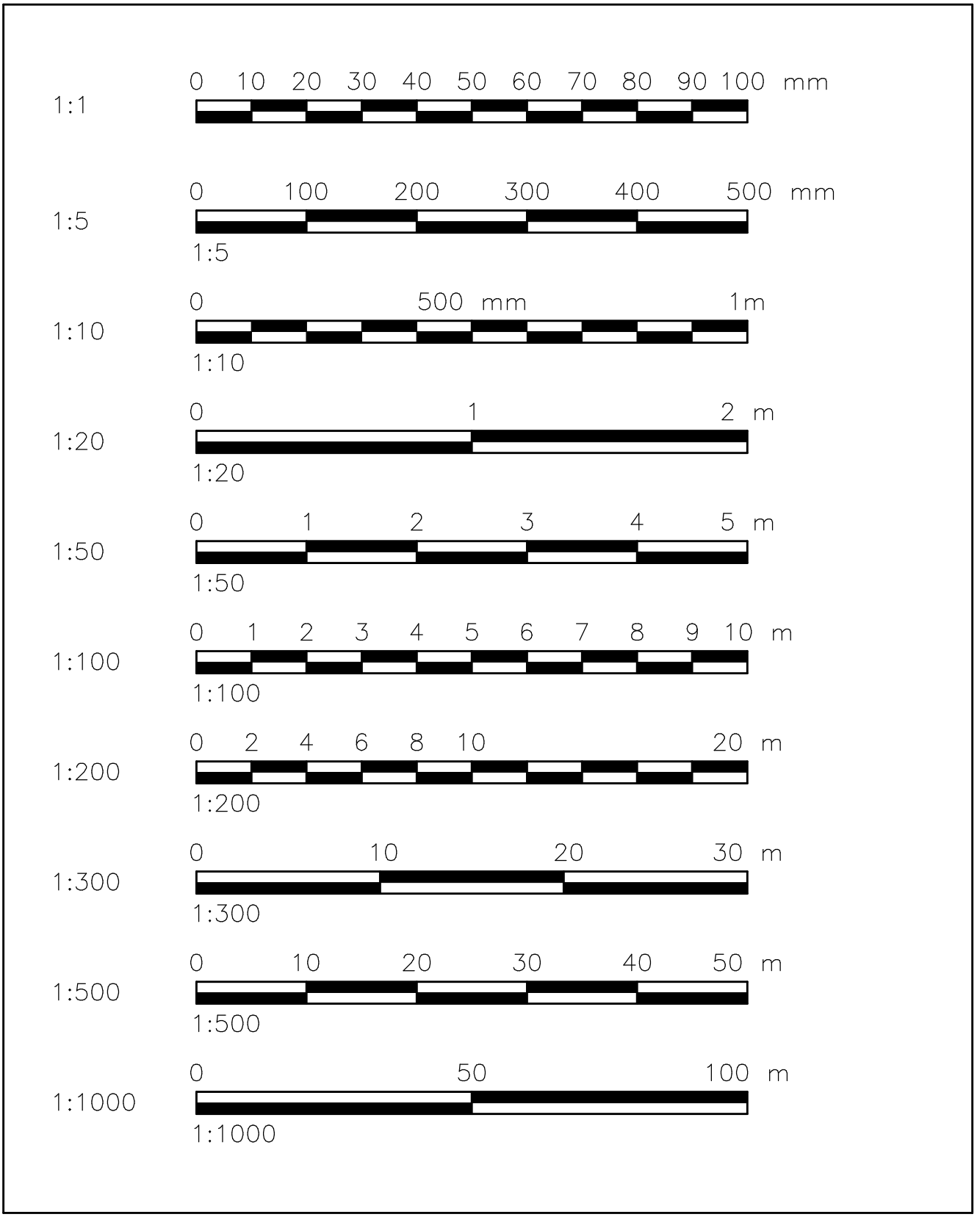
NOTE:

ALL DIMENSION VALUES ARE IN MILLIMETERS (mm).



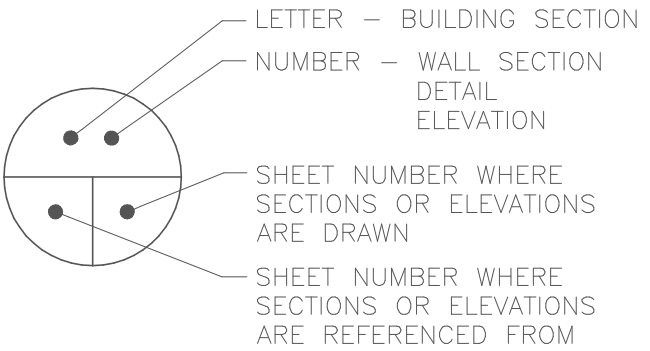
IN–HOUSE TITLE/REVISION BLOCK

NOT TO SCALE

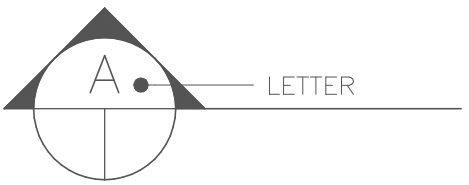


METRIC GRAPHIC SCALES

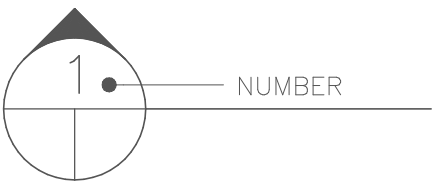
REFERENCE SYMBOLS



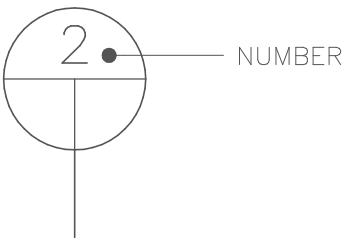
BUILDING SECTION



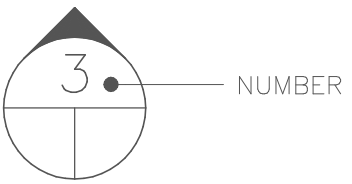
WALL SECTION



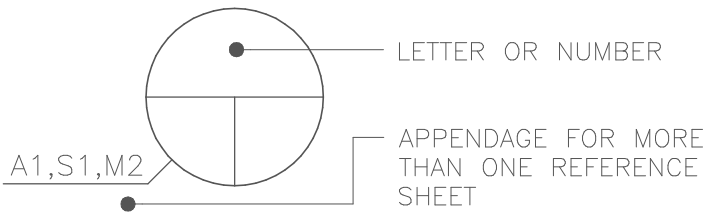
DETAIL SECTION



ELEVATION



DRAWING TITLE



DRAWING REFERENCE SYMBOLS

V. APPENDIX B: PACDIV DESIGN BRANCH METRIC PARAMETERS

CODE 04G ENGINEERING SYSTEMS METRIC PARAMETERS

A. GENERAL INFORMATION

1. Guidance for drawing sheet sizes are in Section II. Design Documents Preparation.

2. Graphic samples of drawing sheets are in Appendix A - 6 and scales and reference symbols are in Appendix A - 7.

B. POINT OF CONTACT

Point of contact on metric policies on drawing sheet and graphic requirements is the Engineering Systems Manager.

CODE 401 ARCHITECTURAL BRANCH METRIC PARAMETERS

A. GENERAL INFORMATION

1. All design and calculations, as much as possible, shall adhere to the applicable international metric standards of the "System of International Units" (SI).

   Design professionals must use common sense and professional judgment when converting "Inch-Pound" (IP**)** standards to SI units. Not all conversions are logical and intuitive during the metrication period. It will require the design professional's understanding and experience in metric. Manufacturers may set their own dimensional standards and procedures of metric-size products. (IP products are usually manufactured to comply with industry standards) The design professional must research dimensional standards and policies on metric and converted metric products to avoid design and product construction conflicts and discrepancies.

2. Metric design based on 600 x 600 mm planning grid is preferred. The designer must strive to use as many "hard metric" products as possible. Where metric products are not available or determined to be uneconomical by research and design analysis, "soft metric" (converted) metric products will be acceptable.

3. The Cox Bill requires concrete masonry units and recessed lighting fixtures to be designed in soft metric to allow for construction using IP unit products.

B. REFERENCES

1. AIA Master Systems, MASTERMETRIC, second edition, Jul 1995.

2. ASTM E 621, Standard Practice for Use of Metric (SI) Units in Building Design and Construction.

3. ASTM E 380, Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System).

4. General Services Administration (GSA), Office of Design and Construction, Metric Design Guide.

C. DRAWINGS

1. Use only one unit of measure on the drawing. The unit of measure should be in millimeter (mm) except for large scale site plans or cartographic drawings where the unit of measure will be in meters (m).

2. Omit unit symbols such as "mm" (or "m"), except for detail notes, and provide a general note "All linear dimensions are in millimeters (or meters) unless otherwise noted" on the drawing sheet.

3. All dimensions of architectural materials and products on the drawings will be in "hard metric" unless conditions are critical to a point where "soft metric" units will be required and to comply with the Cox Bill to allow concrete masonry units and recessed light fixtures fabricated in IP units. See paragraph D. Codes and Standards guidance on "soft metric" units. Refer to NAVFAC Metric Product Starter List which provides a list of manufacturers with metric products.

4. See pages B - 1.c, B - 1.d, B - 1.e, B - 1.f, and B - 1.g on sample drawings in metric.

D. CODES AND STANDARDS

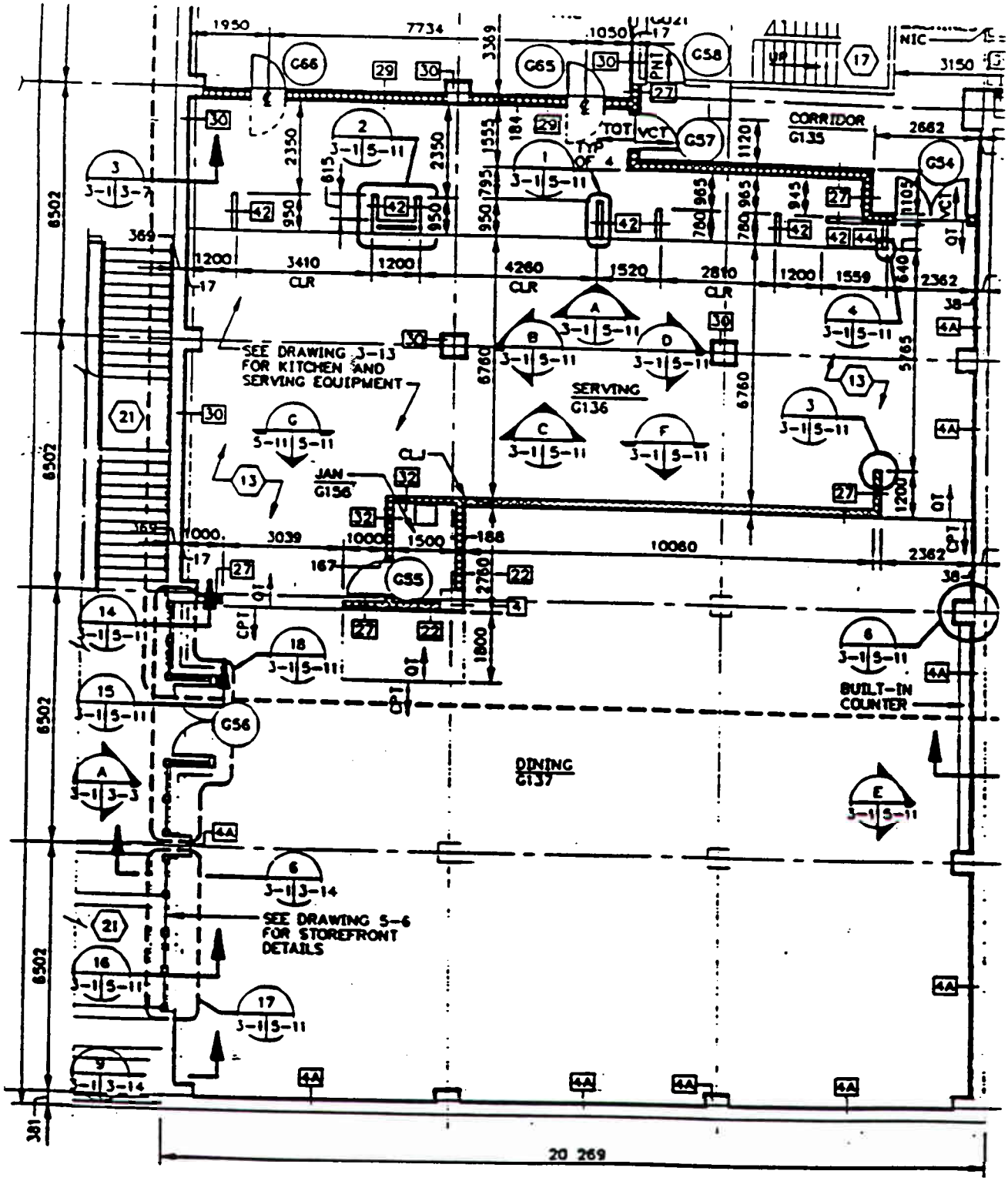
1. 90% of codes and standards are converted to metric.

2. When complying to codes and standards, the metric design shall meet or exceed minimum requirements before rounding the units. When minimum requirements of codes and standards are in IP units, metric calculations shall meet or exceed converted metric equivalent of the IP units.

E. POINT OF CONTACT

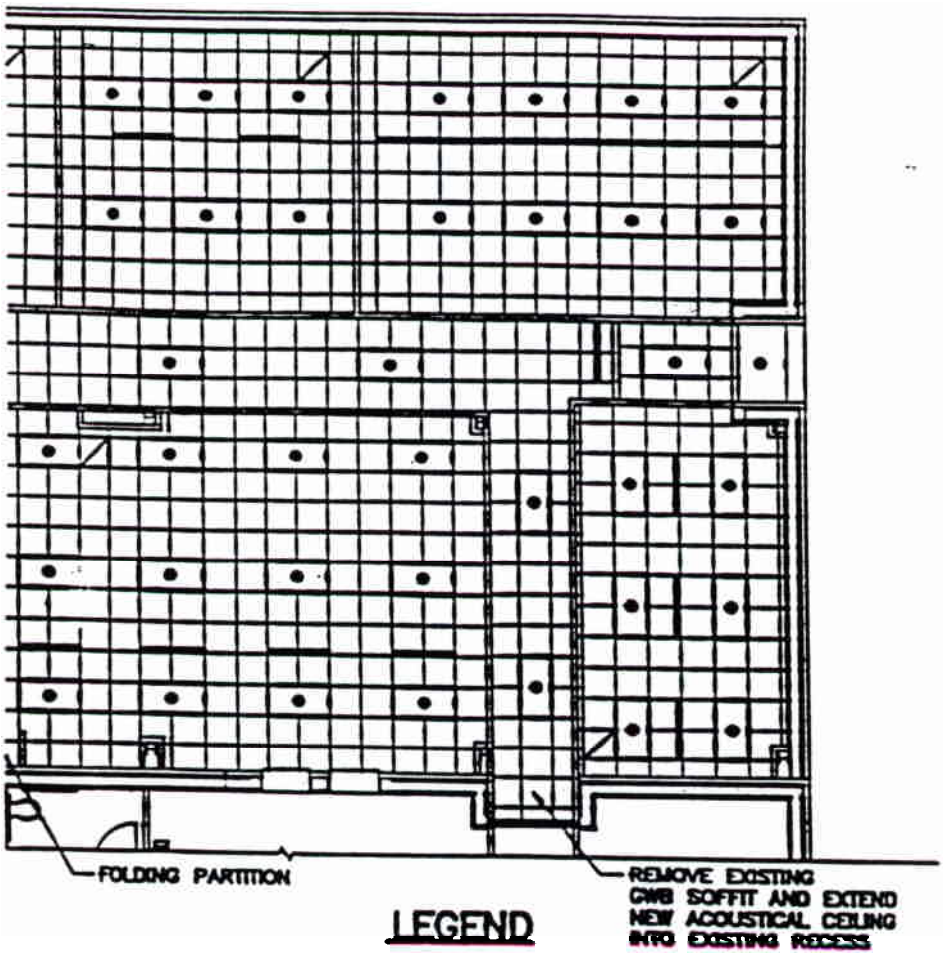
Point of contact on metric policies on architectural design is PACDIV Architectural Branch Manager.

ARCHITECTURAL / RENOVATION PLAN



B - 1.c

ARCHITECTURAL / REFLECTED CEILING



LEGEND

600 X 600 ACOUST. CEILING & GRID

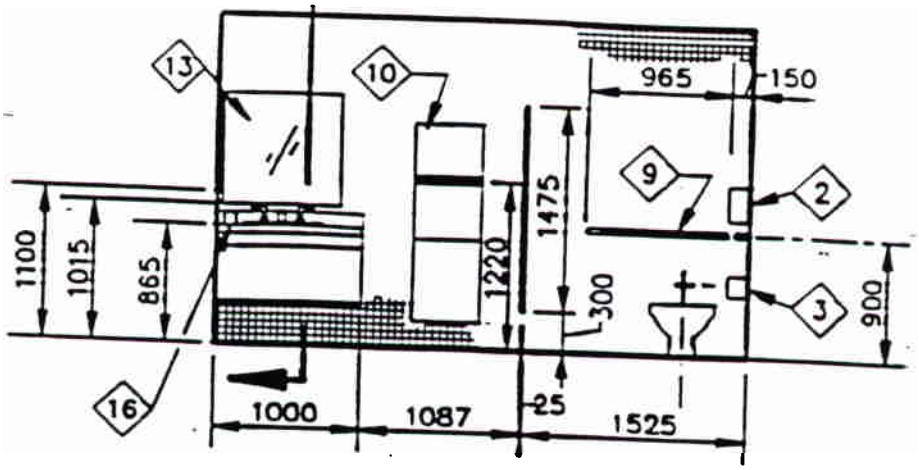
600 X 1200 FLUORESCENT LIGHT FIXTURE

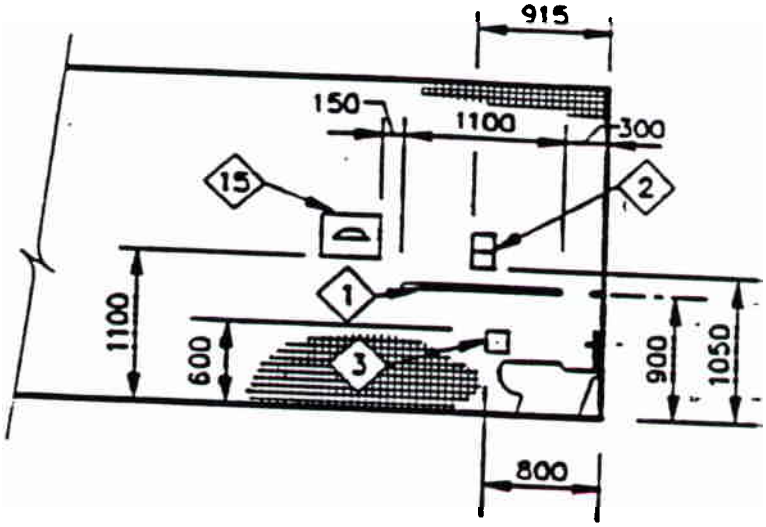
LINEAR DIFFUSER

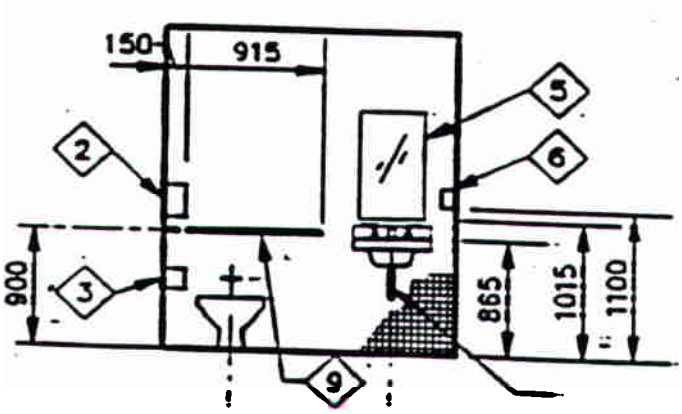
RECESSED SOFFIT LIGHT FIXTURE

RETURN/EXHAUST AIR GRILLE

ARCHITECTURAL / ELEVATION (RESTROOM)

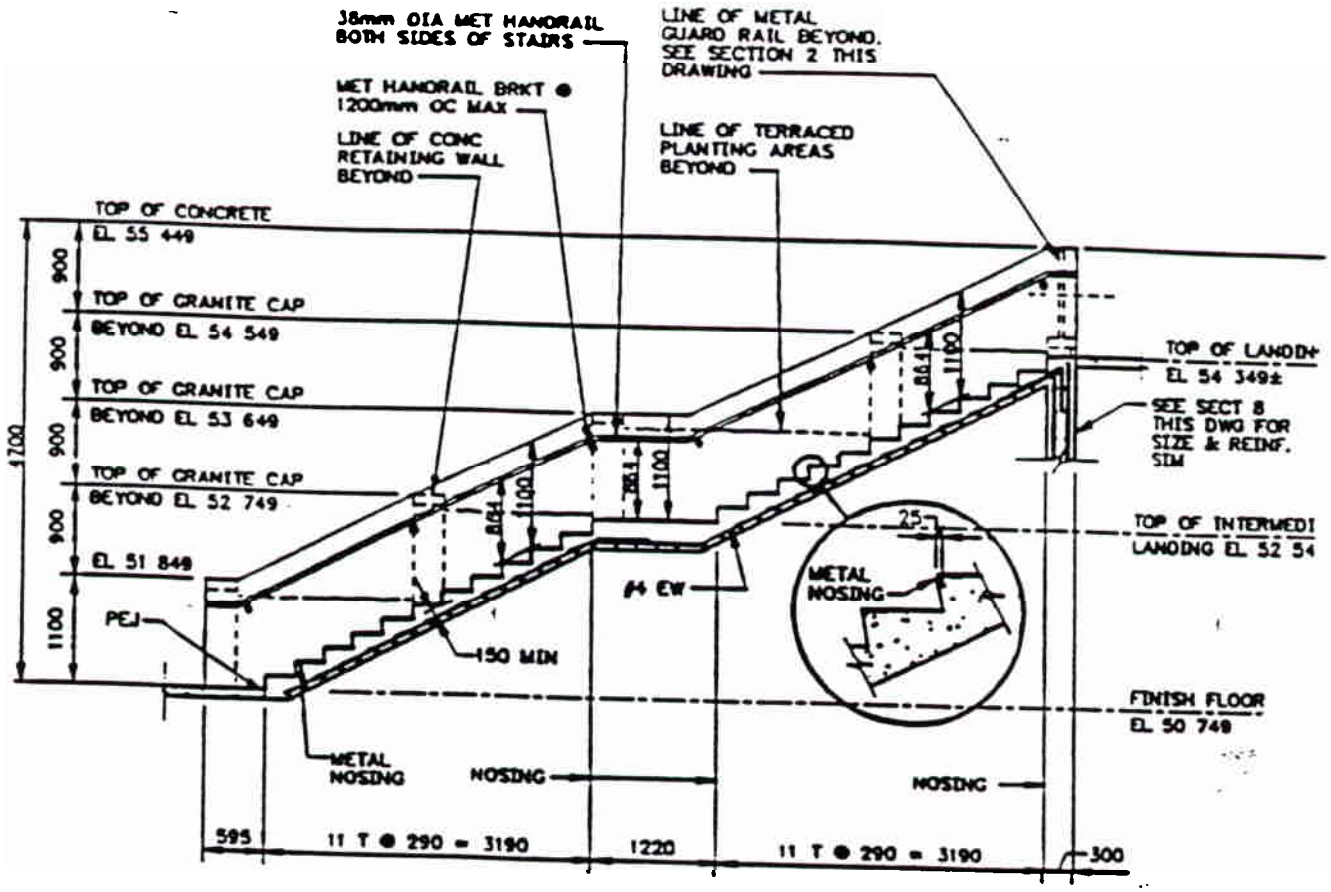




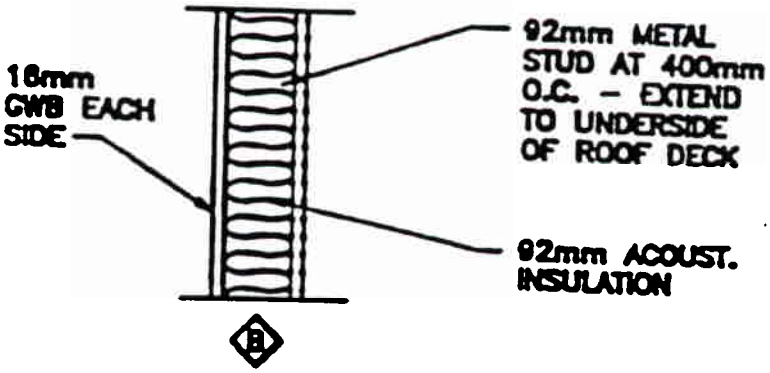


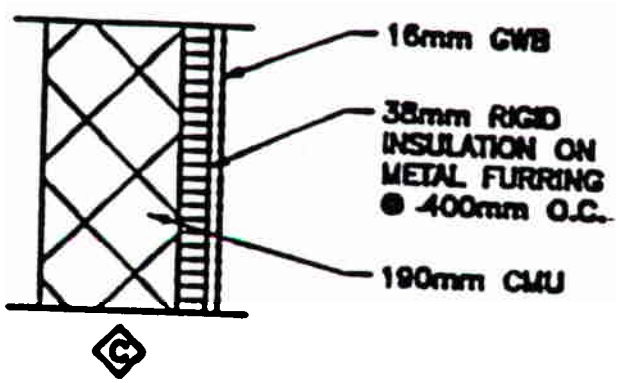
B - 1.e

ARCHITECTURAL / STAIR SECTION



ARCHITECTURAL / WALL SECTION





CODE 402 STRUCTURAL BRANCH METRIC PARAMETERS

A. DESIGN ANALYSIS

1. All calculations should be made using SI units. However, where some industry standards are available only in IP units, and until such time when these are converted, calculations may be done in IP units with final answers converted to SI metric.

2. All engineering materials and products shall be specified in SI metric units. See Conversion Factors (Structural) and Metric Conversion Guide (Structural) provided herein.

B. DRAWINGS

1. Do not use dual units (metric and inch-pound) in dimensioning.

2. See also Section II. DESIGN DOCUMENTS PREPARATIONS.

C. SPECIFICATIONS

1. Ensure that a list of "hard metric" products (those that change to standardized metric sizes) is included in the contract documents.

D. COST ESTIMATES

1. Do not increase cost allowances for construction. While metrication may add a small amount to project costs (some estimate 1 percent), the difference should be within the cost estimate's margin of error.

E. POINT OF CONTACT

Point of contact on metric policies on structural design is PACDIV Structural Branch Manager.

STRUCTURAL CONVERSION FACTORS			
QUANTITY	FROM INCH-LBS	TO METRIC	MULTIPLY BY
Acceleration	ft/sec^2	m/s^2	0.3048
* Angle	degree	radian degree	0.017 453 3 (same as IP unit)
Bending moment, Torque	ft-lb ft-kip	N-m kN-m	1.355 828 1.355 828
Concrete strength	ksi	MPa	6.894 757
Force	lb kip	N kN	4.448 222 4.448 222
Force/unit length	plf klf	N/m kg/m	14.593 9 14.593 9
Mass density	pcf	kg/m^3	16.018 5
Mass/unit area	psf	kg/m^2	4.882 43
Mass/unit length	plf	kg/m	1.488 16
Mass	lb kip	kg metric ton	0.453 592 0.453 592
Moment of mass	lb-ft	kg-m	0.138 255
Moment of inertia	$lb\text{-}ft^2$	$kN\text{-}m^2$	0.042 140 1
Momentum	lb-ft/sec	kg-m/s	0.138 255 0
Pressure, stress, Modulus of Elasticity	psf ksf psi ksi	Pa kPa kPa MPa	47.880 3 47.880 3 6.894 76 6.894 76
Second moment Of area	in^4	mm^4	416 231
Section modulus	in^3	mm^3	16 387.064
Velocity	ft/sec mph	m/s m/s	0.304 80 0.447 04
Volume	cu. in. cu. ft. cu. yd.	cm^3 m^3 m^3	16.387 064 0.028 317 0.764 555

* Note: Angles in metric may be expressed in either radians or degrees.

USA STEEL REINFORCING BAR SIZES					
MATERIAL	PRODUCT	METRIC BAR Size	As (cm^2)	IP EQUIV. Size	COMMENTS
Steel	Rebars	#10 #13 #16 #19 #22 #25 #29 #32 #36 #43 #57	0.7097 1.290 2.000 2.839 3.871 5.097 6.452 8.194 10.064 14.516 25.806	#3 #4 #5 #6 #7 #8 #9 #10 #11 #14 #18	Listed are Soft Metric Rebar sizes as adopted by the reinforcing steel industry, conforming to AASHTO M31M and ASTM A615M specifications *Metric Rebar Design and Detailing Data* is available from Concrete Reinforcing Steel Institute (CRSI). Phone: (708) 517-1200

JIS STEEL REINFORCING BAR SIZES (Japanese rebar sizes, used only for projects in Japan)						
MATERIAL	PRODUCT	BAR Size	DIAMETER D (mm)	AREA A (cm^2)	EQUIVALENT I-P SIZE A (in^2)	Size #
Steel	Rebars	D6 D10 D13 D16 D19 D22 D25 D29 D32 D35 D38 D41	6.35 9.53 12.7 15.9 19.1 22.2 25.4 28.6 31.8 34.9 38.1 41.3	0.3167 0.7133 1.267 1.986 2.865 3.871 5.067 6.424 7.942 9.566 11.40 13.40	0.0491 0.1106 0.1964 0.3078 0.4441 0.6000 0.7854 0.9957 1.2310 1.4827 1.7670 2.0770	- 3 4 5 6 7 8 9 10- 11+ 11- 14-

STEEL STRUCTURAL SHAPES AND PRODUCTS				
MATERIAL	PRODUCT	I-P UNIT	SI UNIT	COMMENTS
Steel	Structural Shapes (Series W, M, S, HP, C, and MC)	inch lbs/ft	mm kg/m	Use converted metric for sizes and weights. Actual dimensions are rounded to the nearest mm; masses, rounded to the nearest kg/m. But nominal depth of each shape is rounded to 10 mm. (Reference: May-June 1995 issue of Metric in Construction). e.g.: W10x23 = W26x49
Steel	Angles	inch	mm	Leg sizes are converted metric rounded to the nearest mm, and thickness rounded to the nearest 0.1 mm.
Steel	Pipes	inch	mm	Converted with new designations based on ISO DN (diameter nominal) sizes, where 1 inch = 25 mm. Eg.: A 6-inch standard pipe will be a DN 150 pipe, and a 6-inch extra-strong pipe will be a DNX 150 pipe.
Steel	High-Strength Bolts, Nuts, Washers	inch	mm	Hard metric series designated by an “M” prefix followed by the actual diameter in millimeters: M16, M20, M22, M24, M27, M30 and M36.
Metal	Sheet Metal	inch gage	mm	Converted metric, rounded to the nearest 0.05 mm, if below 1.0 mm, or to nearest 0.1 mm, if above 1.0 mm.

WELDING				
MATERIAL	PRODUCT Electrodes	I-P UNIT ksi	SI UNIT MPa	COMMENTS
Welding	E60 E70 E80 E90 E100	60 70 80 90 100	410 480 550 620 690	Fillet weld sizes are expressed in 1 mm increments up to 8 mm; 2 mm increments from 8-20 mm; 5 mm increments from 20-40 mm; and 10 mm increments beyond 40 mm.

CONCRETE AND MASONRY				
MATERIAL	PRODUCT	I-P UNIT	SI UNIT	COMMENTS
Concrete	Concrete Strength	2900 psi 3626 psi 4351 psi 5076 psi 5801 psi 6526 psi	20 MPa 25 MPa 30 MPa 35 MPa 40 MPa 45 MPa	Concrete strengths in SI units are specified in 5 MPa increments, per ACI 318. Equivalent I-P units in psi are as shown.
Masonry	CMU sizes	Nominal 8x8x16 in.	Actual (Rounded) 190x190x390	Specify rounded actual sizes, converted from I-P sized blocks, but use hard metric for overall wall and opening dimensions.

LUMBER				
MATERIAL	PRODUCT	I-P UNIT	SI UNT	COMMENTS
Lumber	Wood Studs Plywood Sheet	Nominal 2x4 inches Modular 48x96 inches	Actual (Rounded) 38x89 mm Modular 1200x2400 mm	Use rounded actual sizes for lumber and modular metric sheet sizes for plywood. (Reference: AIA “Masterspec” *Weights and Measure Policy,* dated 8/94.

WELDED WIRE FABRIC IN IP UNITS				
Style Designation (IP Units)	Spacing (inches)		Diameter (inches)	
	Longitudinal	Transverse	Longitudinal	Transverse
6x6 – W1.4 x W1.4	6	6	.135	.135
6x6 – W2.1 x W2.1	6	6	.162	.162
6x6 – W2.9 x W2.9	6	6	.192	.192
6x6 – W4 x W4	6	6	.225	.225
4x4 – W1.4 x W1.4	4	4	.135	.135
4x4 – W2.1 x W2.1	4	4	.162	.162
4x4 – W2.9 x W2.9	4	4	.192	.192
4x4 – W4 x W4	4	4	.225	.225

WELDED WIRE FABRIC IN SI UNITS				
Style Designation (SI Units)	Spacing (mm)		Diameter (mm)	
	Longitudinal	Transverse	Longitudinal	Transverse
152x152 – MW9.1 x MW9.1	152	152	3.4	3.4
152x152– MW13.3 x MW13.3	152	152	4.1	4.1
152x152 – MW18.7 x MW13.7	152	152	4.8	4.8
152x152 – MW25.8 x MW25.8	152	152	5.7	5.7
102x102 – MW9.1 x MW9.1	102	102	3.4	3.4
102x102 – MW13.3 x MW13.3	102	102	4.1	4.1
102x102 – MW18.7 x MW18.7	102	102	4.8	4.8
102x102 – MW25.8 x MW25.8	102	102	5.7	5.7

* Gage sizes from ASTM A 510M for carbon steel. See ASTM B 3 for copper gage sizes.

CODE 403 MECHANICAL BRANCH METRIC PARAMETERS

A. DESIGN CALCULATIONS:

All design calculations (e.g. air conditioning load calculations, piping system sizing, duct sizing, etc.) shall be done in metric using metric coefficients and factors. Where product data or equation coefficients are not available in metric, calculations based on I-P units will be allowed with the end result converted to metric.

B. GENERAL NOTES FOR CONVERTING FROM INCH-POUND (I-P) TO METRIC:

Where code requirements or applicable standards reflect minimum or maximum values in I-P units, those minimum or maximum values shall be maintained when converted to metric. This is also applicable for required clearances, dimensions, etc.

C. MATERIAL:

1. PIPE:

The physical pipe size will not change but will be relabeled in metric (see attached table "Recommended Nominal Metric Sizes For Pipe Products"). The metric equivalent is called DN for "diameter nominal" (example: a 6-inch standard pipe will be relabeled as DN150 pipe). For specifications and other project documentation (with the exception of drawings) the metric designation for pipe shall be written as DN150 as opposed to 150 mm. On the project drawings and sketches where all units are understood to be shown in millimeters, the pipe size shall be shown as 150 (without the "mm").

Pipe cross sections will not change. Fittings, flanges, couplings, valves, and other piping components will also be relabeled following the same format as the piping.

All product dimensions covered by ASME B16.1 and ASME B1.20.1 remain unchanged. (Note: Pipe fittings manufactured to ASME B16.3 are threaded with ASME B1.20.1 pipe threads.) The following examples showing metric designation for pipe and fittings are provided:

example: a 6-inch x 6-inch x 4-inch, Class 125, Grade A, reducing tee per ASME B16.1 is designated in metric as a DN150 x DN150 x DN100, Class 125, Grade A, reducing tee per ASME B16.1.

example: a 2-inch Class 150 malleable iron 90 degree elbow per ASME B16.3 is designated in metric as a DN50 Class 150 malleable iron 90 degree elbow per ASME B16.3.

example: a specification calling for a minimum 2-inch drain valve is designated in metric as a minimum DN50 drain valve.

2. SHEET METAL:

The physical size (thickness) of the sheet metal will not change but will be soft converted to tenths of a millimeter. The designation for sheet metal will change from "gage" to millimeters.

D. POINT OF CONTACT

Point of contact on metric policies on mechanical design is PACDIV Mechanical Branch Manager.

RECOMMENDED NOMINAL METRIC SIZES FOR PIPE PRODUCTS			
NPS (inches)	DN (mm)	NPS (inches)	DN (mm)
1/8	6	8	200
3/16	7	10	250
1/4	8	12	300
3/8	10	14	350
1/2	15	16	400
5/8	18	18	450
3/4	20	20	500
1	25	24	600
1 1/4	32	28	700
1 1/2	40	30	750
2	50	32	800
2 1/2	65	36	900
3	80	40	1000
3 1/2	90	44	1100
4	100	48	1200
4 1/2	115	52	1300
5	125	56	1400
6	150	60	1500

For pipe over 60 inches, use 1 inch equals 25 mm
NPS is the inch-pound designation for "Nominal Pipe Size"
DN is the metric designation for "Diameter Nominal"

Source: Construction Metrication Council, National Institute of Building Sciences, August 1993

MECHANICAL CONVERSION UNITS			
Type of Measurement	IP Unit	SI Unit	Conversion Factor (IP to SI) - multiply by:
Temperatures	degrees F	degrees C	5/9(t - 32)
Pressure	psig	kPa	6.895
	inches of mercury	kPa	3.386
	inch wg	Pa	249
	feet of water column	kPa	2.984
Volume	gal	L	3.785
	barrel (bbl) (fuel oil - 42 gal)	L	158.987
Flow	gpm	L/s	0.06308
Rate of Heat Flow, Refrigeration Capacity	tons	kW	3.517
	Btuh	W kW	0.2930 2.93×10^{4}
Air Flow	cfm	L/s	0.4719
Sheet Metal	gage (inches)	mm	25.4
Fin Spacing	fins per inch	mm oc	
Motor	hp	kW	0.746
Velocity	fpm	m/s	5.08×10^{3}

CODE 404 ELECTRICAL BRANCH METRIC PARAMETERS

A. GENERAL INFORMATION

1. 1996 National Electrical Code (NEC) is written using inch-pound (I-P) units of measure. Where the specified I-P clearances, dimensions, etc. reflect minimum or maximum values, those minimum and maximum values shall be maintained when converted to metric. Similarly where other codes, standards, professional and trade organization documents are written using the I-P system, the specified minimum and maximum values shall be maintained.

2. In many electrical engineering designs, "exact" equipment dimensions are normally not specified since many vary between manufacturers. Where equipment space allocations are critical, minimum and maximum values could be use to identify equipment dimensions that should not be exceeded. Where electrical equipment are available in metric sizes, specify a minimum of three manufacturers. For example, lighting fixtures for lay-in ceilings are available in 600 X 600 mm and 600 X 1200 mm metric sizes. A list of manufacturers are shown in the GSA M2 Metric Design Guide. Other manufacturer may also be available.

B. METRIC UNITS AND CONVERSION GUIDES

1. Metric conversion to the International System of Units (SI) will not affect some of the electrical unit designations such as current (amperes), potential (volts), frequency (Hertz) and power (watt). However, many have changed. Refer to the reference documents such as American Institute of Architects, MASTERMETRIC, Second Edition July 1995 and ASTM E-380-9a, Standard Practice for Use of the International System of Units for the proper SI unit designations, symbols and conversion factors.

2. Electrical wire sizes will remain as American Wire Gauge (AWG), until further notice, and will not be specified in metric sizes. Note that AWG is a neutral unit of measurement which indicates thickness but in itself is neither SI nor I-P.

3. 1996 NEC will contain Fine Print Notes (FPN) that includes nominal metric sizes for various types of conduits and tubing. Physically, the conduits and tubing will not change. They have been reclassified by nominal metric sizes. For conduits not covered by the 1999 NEC, refer to industry standards such as NEMA. Nominal I-P conduit and tubing sizes and their equivalent nominal metric designations are as follows:

1/2" = 16 mm	1-1/2" = 41 mm	3-1/2" = 91 mm
3/4" = 21 mm	2" = 53 mm	4" = 103 mm
1" = 27 mm	2-1/2" = 63 mm	5" = 129 mm
1-1/4" = 35 mm	3" = 78 mm	6" = 155 mm

C. POINT OF CONTACT

Point of contact on metric policies on electrical design is PACDIV Electrical Branch Manager.

CODE 405 CIVIL BRANCH METRIC PARAMETERS

A. SURVEYING

1. Horizontal Measurements

   Use millimeters, meters and kilometers. Use U.S. feet (not international feet) when converting back to IP units.

2. Vertical Measurements

   Use meters for elevations. Base the reference datum as zero (e.g. MLLW =0.000 meters even if it was MLLW = 100 feet). Convert all other BM elevations accordingly. (If BM is 110.235 ft based on an assumed datum of MLLW = 100.00 feet, then the BM should read 3.120 meters, MLLW).

B. SOILS INVESTIGATION

Use lengths, forces, and pressures in SI metric units. Data such as sampling depths, blows per 300 mm and soil strength, etc. and reports should be in SI metric. However, use N values if they are developed based on 140 lb weight falling 30 inches on Standard Penetration Test (SPT) sampler. CBR values should be still be reported based on IP system.

C. PAVEMENT DESIGN AND EARTHWORK

Use metric design where metric products and design standards are available.

D. WATER SUPPLY AND SEWER

For pipe sizing, design can be in IP and converted into SI metric, i.e. converted (soft) metric.

E. DRAINAGE DESIGN

Design can be in metric after converting input such as rainfall intensity from IP to metric. However, much of the design charts and other input will be IP. The results can then be converted into metric design.

F. USE OF UNITS

See Structural, Mechanical and Fire Protections design parameters for typical units.

G. POINT OF CONTACT

Point of contact on metric policies on civil design is PACDIV Civil Branch Manager.

CODE 406 SPECIFICATIONS/COST BRANCH METRIC PARAMETERS

A. SPECIFICATIONS METRIC UNITS

1. Use same unit names, symbols and numerical designations in the drawings and specifications.

2. Do not use dual units (metric and inch-pound) in specifications**.**

3. Use nominal metric dimensions established by the manufacturer or industry.

4 Be aware of drawing requirements for life safety and other code requirements. Material thickness must comply with code requirements unless accepted by a testing agency.

5 Round off (soft) metric units to a 10 mm numerical base for product sizes and dimensions. Use "0" or "5" for the "one integer" (from 1, 10, 100, etc.) of the numerical arrangement. The greatest numerical value of 2.5 mm between "0" and "5" is less than 1/8 inch. Consult with the designer to determine use of "0" or "5" mm of the linear dimensions.

As an example for non-code design, towel bar sizes of 24 and 36 inches may be rounded in metric units of 600 and 900 mm (actual conversion of 609.6 and 914.4 mm).

For life safety and other code requirements such as a 5/8 inch thick gypsum ,

6. The paragraph “SCHEDULE” at the end of UFGS technical sections list both SI and IP conversion units. Edit the paragraph and add other units used in the sections.

7 Material thickness of units less than 3 mm (1/8 inch) for coatings, finishes, sheet metal, roofing materials, vapor barriers are usually identified in the specifications rather than the drawings.

8. Conversion Tables for specifications and cost estimating are included in PACDIV 406 Branch parameters:

Metric Units: Rule of Thumb
Area
Coating and Film Thickness
Mass (weight): Avoirdupois
Temperature
Volume: Dry
Volume: Liquid
Wind Velocity

B. MATERIALS AND PRODUCTS

1. Specify materials and products in hard metric, soft metric, or nominal metric. The “Cox Bill” known as the Savings in Construction Act of 1996 does not allow recessed light fixtures and concrete block to be designed and specified in hard metric.

2. Most building materials and products are relabeled in soft metric or nominal metric units. Product availability should not be a significant problem. Verify the availability of materials and products to prevent subsequent problems.

3. Fire, acoustic, and thermal ratings metric products and design systems will not required recalculation or testing. Examples are gypsum board, fire doors, fire rated ceiling tile, and acoustical rated partition.

C. COST ESTIMATING

1. Use R. S. Means Company, Inc. manual "How to Estimate With Metric Units" for Part I: Metric estimating guidelines, Part II: Metric Estimating by Master Format Division, and Part III: Metric In Design. Part III includes Appendices A: Metric Conversion Tables, B: Metric Product Sources, C: Metric References, and D: Professional Associations.

C. POINT OF CONTACT

Point of contact on metric policies on specifications and cost is PACDIV Specifications and Cost Branch Manager.

METRIC UNITS: RULE OF THUMB				
Measure	Metric Unit	Symbol	Rules of Thumb (approximate IP units)	Remarks
Area	square meter	m^2	1 m^2 = 10 sq ft	
Length	meter millimeter	m mm	1 m = 3 feet 1 mm = thickness of dime 25 mm = 1 inch 300 mm = 1 foot	
Mass :avoirdupois (weight)	kilogram	kg	1 kg = 2.2 pounds 1000 kg = 2200 pounds (metric ton)	
Pressure:	Pascal kilopascal	Pa kPa	10 kPa = 1.45 psi	
Slope	percent unit ratio	% mm: mm mm: m m: m	% (sine) inch: inch inch: feet feet: feet	
Temperature	degree Celsius	^oC	1 ^oC = 1.8^o F + 32 F = 33.8^o F 10 ^oC = 18^o F+ 32^o F = 50 ^{o} F	100 water boils (212 ^{o} F) 40 is hot (104^o F) 37 body (98.6 ^{o} F) 30 is warm (86^o F) 20 is nice (68^o F) 10 is cool (50^o F) 0 is ice (32^o F)
Volume (dry)	cubic meter	m^3	1 m^3 = 35 cubic feet	
Volume (liquid)	Liter	L	1 L = one quart	

AREA					
Square feet (sf)	Square meter (m^2)	Square feet (sf)	Square meter (m^2)	Square feet (sf)	Square meter (m^2)
1	9.290^{-02}	100	9.290	10,000	929.034
2	0.185	200	18.580	20,000	1858.060
3	0.278	300	27.870	30,000	2787.091
4	0.371	400	37.161	40,000	3716.121
5	0.464	500	46.451	50,000	4645.152
6	0.557	600	55.741	60,000	5574.182
7	0.650	700	65.032	70,000	6503.212
8	0.743	800	74.322	80,000	7432.243
9	0.836	900	83.612	90,000	8361.273
10	0.929	1,000	92.903	100,000	9290.304
20	1.858	2,000	185.806		
30	2.787	3,000	278.710		
40	3.716	4,000	371.613		
50	4.645	5,000	464.517		
60	5.574	6,000	557.420		
70	6.503	7,000	650.323		
80	7.432	8,000	743.227		
90	8.361	9,000	836.130		

ft^2 = 0.093 m^2 yd^2 = 0.836 m^2 roof square = (100) x 0.093 = 9.3 m^2)	m^2 = 10.764 sf

COATING AND FILM THICKNESS

mils	to mm	microns	Microns	mm to	mils
0.5	0.0127	13	10	0.01	0.4
1.0	0.0254	25	20	0.02	0.8
1.5	0.0381	38	30	0.03	1.2
2.0	0.0508	51	40	0.04	1.6
2.5	0.0635	64	50	0.05	2.0
3.0	0.0762	76	60	0.06	2.4
3.5	0.0889	89	70	0.07	2.8
4.0	0.1016	102	80	0.08	3.2
4.5	0.1143	114	90	0.09	3.6
5.0	0.1270	127	100	0.1	3.9
6.0	0.1524	152	200	0.2	7.9
7.0	0.1778	178	300	0.3	11.8
8.0	0.2032	203	400	0.4	15.8
9.0	0.2286	229	500	0.5	19.7
10.0	0.254	254	600	0.6	23.6
20.0	0.508	508	700	0.7	27.6
30.0	0.762	762	800	0.8	31.5
40.0	1.16	1016	900	0.9	35.5
50.0	1.27	1270			
			1000	1	39.4
60.0	1.524	1524	1200	1.2	47.3
70.0	1.778	1778	1400	1.3	55.2
80.0	2.032	2032	1600	1.6	63.0
90.0	2.286	2286	1800	1.8	70.9
100.0	2.54	2540			
			2000	2	78.8
110.0	2.794	2794	2500	2.5	98.5
120.0	3.048	3048	3000	3	118.2
130.0	3.302	3302	3500	3.5	137.9
140.0	3.556	3556	4000	4	157.6
150.0	3.81	3810			

1 mil = 0.001 inch
1 mil = 0.0254 mm = 25.4 microns

1 mm = 1000 microns = 39.4 mils
1 micron = 0.001 mm = 0.0394 mils

MASS (WEIGHT) : AVOIRDUPOIS					
Ounces (oz)	Gram (g)	Pounds (lb)	Kilogram (kg)	Pounds (lb)	Kilogram (kg)
1	28.35	1	0.453	100	45.36
2	56.70	2	0.907	200	90.72
3	85.05	3	1.361	300	136.08
4	113.4	4	1.814	400	181.44
5	141.75	5	2.268	500	226.8
6	170.1	6	2.738	600	272.16
7	198.45	7	3.175	700	317.52
8	226.8	8	3.629	800	362.88
9	255.15	9	4.082	900	408.24
10	283.5	10	4.536	1000	453.6
11	311.85	20	9.072	2000	907.2
12	340.2	30	13.608	3000	1360.8
13	366.55	40	18.144	4000	1814.4
14	396.9	50	22.68	5000	2268
15	425.25	60	27.216	6000	2721.6
16	453.6	70	31.752	7000	3175.2
		80	36.288	8000	3628.8
		90	40.824	9000	4082.4

1 oz = 28.349 52 g 0.028 349 52 kg 1 lb = 0.453 592 kg	1 g = 0.035 oz 1 kg = 2.2 lb

MASS PER UNIT AREA	MASS PER UNIT LENGTH
1 oz/ft^2 x 0.305 1 = 1kg/m^2 1 lb/ft^2 = 4.882 kg/m^2	1 lb/in x 17 858 = 1kg/m 1 lb/ft = 1.488 kg/m

TEMPERATURE	
Celsius (Centigrade) ^0C	Fahrenheit ^0F
- 30	- 22.0
- 20	- 4.0
- 10	+ 14.0
0	32.0
1	33.8
2	35.6
3	37.4
4	39.2
5	41.0
6	42.8
7	44.6
8	46.4
9	48.2
10	50.0
20	68.0
30	86.0
40	104.0
50	122.0
60	140.0
70	158.0
80	176.0
90	194.0
100	212.0
200	392.0
300	540.0
$^0C = \frac{(^0F - 32)}{1.8}$ $1\ ^0C = 1.8\ ^0F$	$^0F = (^0C \times 1.8) + 32$ $1\ ^0F = 0.56\ ^0C$

VOLUME: DRY		
Cubic Meter (m^3 or cu. m)	Cubic Feet (ft^3 or cu. ft.)	Cubic Yard (yd^3 or cu. yd.)
1	35.31	1.31
2	70.62	2.62
3	105.94	3.92
4	141.26	5.23
5	176.57	6.54
6	211.89	7.85
7	247.20	9.16
8	282.52	10.46
9	317.83	11.77
10	353.14	13.08
20	706.29	26.16
30	1059.43	39.24
40	1412.58	52.32
50	1756.72	65.40
60	2118.88	78.48
70	2472.01	91.56
80	2825.16	104.37
90	3178.30	117.71
100	3531.45	130.79
200	7062.89	261.59
300	10594.36	392.38
400	14125.78	523.18
500	17657.22	653.97
600	21188.67	784.76
700	24720.12	915.56
800	28251.56	1046.35
900	31783	1177.15
1000	35314.45	1307.94
1 m^3 = 35.315 ft^3 = 1.308 yd^3	1 ft^3 = 0.0283 m^3	1 yd^3 = 0.76455 m^3

VOLUME: LIQUID	
Liters (L)	Gallons (gal)
0	0
10	2.64
20	5.28
30	7.92
40	10.56
50	13.2
60	15.84
70	18.48
80	21.12
90	23.76
100	26.4
200	52.8
300	79.2
400	105.6
500	132
600	158.4
700	184.8
800	211.2
900	237.6
1000	264
2000	528
3000	792
4000	1056
5000	1320
6000	1584
7000	1848
8000	2112
9000	2376

1 L = 0.264 gallons = 1.056 quarts = 2.12 pints	1 gal = 3.788 L 1 qt = 0.946 L 1 pt = 0.47 L

WIND VELOCITY		
mph	Km/hr	m/s
10	16.09	4.47
20	32.18	8.94
30	48.28	13.41
39 Tropical Depression	62.75	17.43
40	64.37	17.88
50	80.46	22.35
60	96.56	26.82
70	112.65	31.29
74 Hurricane	119.06	33.08
80	128.74	35.76
90	144.84	40.23
100	160.93	44.70
105 (Hawaii)	169	46.93
110	177.02	49.17
120	193.12	53.64
130	209.21	58.11
140	225.30	62.58
150	241.40	67.05
160	257.49	71.52
175 (Guam)	281.63	78.23
180	289.68	80.46
190	305.77	84.93
200	321.86	89.40
210	337.96	93.87
220	354.05	98.34
230	370.14	102.81
240	386.24	107.28
250	402.33	111.76
mph x (1.609) = km/hr mph x 0.447 = m/s		

* Wind Force (psf = kPa) - See ASCE 7-95 Standard "Minimum Design Loads for Buildings and Other Structures", 6/6/96 Edition

CODE 408 FIRE PROTECTION ENGINEERING BRANCH METRIC PARAMETERS

A. GENERAL REQUIREMENTS

1. As a rule, fire protection designs and equipment that involve converted metric units shall meet or exceed the intention of applicable codes and standards. Usually, the converted results involve "rounding up" the design or equipment dimensions to meet minimum code.

2. The metric guide does not affect all areas of fire protection engineering. Areas that are not affected include fire ratings, pipe designations, and wire sizes.

   a. Length and width of fire rated walls, doors and ceiling tiles will be in hard metric sizes. However, the thickness of the product will remain unchanged from inch-pound dimensions to maintain its listing/approval.

   b. Pipes will be classified in nominal metric sizes. However, pipe designations will remain as Schedule 30 and Schedule 40 for steel pipes, and Type K, Type L, Type M for copper tube. Minimum wall thickness is specified in NFPA 13.

   c. Electrical wire sizes will remain as American Wire Gauge (AWG).

3. Refer to Appendix B-3 for general information on mechanical requirements for pressure ratings and pipe sizes.

4. Refer to Appendix B-4 for additional information on electrical requirements for conduits, tubing and wire sizes.

B. METRIC UNITS

1. Fire protection designs are not required to use metric units exclusively. Several applications such as water density and flow rates use a combination of inch-pound and metric units. Other applications such as fire ratings and electrical wire sizes use acceptable non-metric units. TABLE 1: METRIC UNITS LIST FOR FIRE PROTECTION shows metric and acceptable non-metric units for design of fire protection projects.

C. DESIGN GUIDANCE AND REQUIREMENTS

The following documents provide guidance and requirements for fire protection designs:

1. Military Handbook 1008B - Fire Protection for Facilities Engineering, Design, and Construction

2. National Fire Codes - National Fire Protection Association (NFPA)

3. Uniform Building Code (UBC)

D. POINT OF CONTACT

Point of contact on metric policies for design of fire protection systems is PACDIV Fire Protection Branch Manager.

TABLE - 1: METRIC UNITS LIST FOR FIRE PROTECTION			
DESIGN APPLICATION	IP UNITS	SI UNITS	ACCEPTABLE NON-METRIC
Air Flow	cfm	L/s	--
Alarm Audio Intensity	db	db	--
Area	ft^2	m^2	--
Density (Water)	gpm/ft^2	--	$(L/min)/m^2$
Distance	ft, in	m, mm	--
Fire Rating	hr	--	hr
Flow Rate (Water)	gpm	L/s	L/min
Friction Loss	psi/ft	bars/m	--
Hazen-Williams coefficient	--	--	--
Head Loss	ft	m	--
Horsepower	hp	kW	--
Hose Stream Demand	gpm	L/s	L/min, m^3/min
K-factor	$(gal/min)(psi)^{1/2}$	$(L/s)(kPa)^{1/2}$	--
Length	ft, in	m, mm	--
Luminous Intensity	cd	cd	--
Orifice Diameter	in	mm	--
Pipe Diameter	in	mm	--
Pressure	psi	kPa, bar	--
Pump Discharge Rate	gpm	L/s	L/min
Temperature	^oF	^oC	--
Time	sec, min, hr	s	min, hr
Voltage	V	V	--
Volume	gal	L	--
Weight	lb	kg	--
Wire Size	AWG	--	AWG

VI. APPENDIX C: DESIGN REFERENCES AND RESOURCES

* Copyright publications
** Voluminous publication

Contact the following for listed design references:

*	Mastermetric	American Institute of Architects The Honolulu Chapter 1128 Nuuanu Ave 1st Floor Honolulu, Hawaii 96817 (808) 545 – 4242
*	ASTM E - 621 Metric (SI) Units	ASTM 1916 Race Street Philadelphia, PA 19103
**	Metric Design Guide (PBS-PQ269)	General Services Administration (GSA) The Wanamaker Building 100 Penn Square East Philadelphia, PA 19107-3396 (215) 656-5822 FAX (215) 656-5836
**	Guide for the Use of the International System of Units (SI) NIST Special Publication 811	Superintendent of Documents U.S. Government Printing Office Washington, D. C. 20402
*	R. S. Means Company, Inc. (How to Estimate With Metric Units)	Construction Publishers & Consultants 100 Construction Plaza, P.O. Box 800 Kingston, MA 02364-0800 (617) 585-7880

VI. APPENDIX C: DESIGN REFERENCES AND RESOURCES

METRIC USAGE IN FEDERAL GOVERNMENT

Presidential Documents

Executive Order 12770 of July 25, 1991

Metric Usage in Federal Government Programs

By the authority vested in me as President by the Constitution and the laws of the United States of America, including the Metric Conversion Act of 1975, Public Law 94-168 (15 U.S.C. 205a *et seq.*) ("the Metric Conversion Act"), as amended by section 5164 of the Omnibus Trade and Competitiveness Act of 1988, Public Law 100-418 ("the Trade and Competitiveness Act"), and in order to implement the congressional designation of the metric system of measurement as the preferred system of weights and measures for United States trade and commerce, it is hereby ordered as follows:

Section 1. *Coordination by the Department of Commerce.* (a) The Secretary of Commerce ("Secretary") is designated to direct and coordinate efforts by Federal departments and agencies to implement Government metric usage in accordance with section 3 of the Metric Conversion Act (15 U.S.C. 205b), as amended by section 5164(b) of the Trade and Competitiveness Act.

(b) In furtherance of his duties under this order, the Secretary is authorized:

(1) to charter an Interagency Council on Metric Policy ("ICMP"), which will assist the Secretary in coordinating Federal Government-wide implementation of this order. Conflicts and questions regarding implementation of this order shall be resolved by the ICMP. The Secretary may establish such subcommittees and subchairs within this Council as may be necessary to carry out the purposes of this order;

(2) to form such advisory committees representing other interests, including State and local governments and the business community, as may be necessary to achieve the maximum beneficial effects of this order; and

(3) to issue guidelines, to promulgate rules and regulations, and to take such actions as may be necessary to carry out the purposes of this order. Regulations promulgated by the Secretary shall function as policy guidelines for other agencies and departments.

(c) The Secretary shall report to the President annually regarding the progress made in implementing this order. The report shall include:

(1) an assessment of progress made by individual Federal agencies towards implementing the purposes underlying this order;

(2) an assessment of the effect that this order has had on achieving the national goal of establishing the metric system as the preferred system of weights and measures for United States trade and commerce; and

(3) on October 1, 1992, any recommendations which the Secretary may have for additional measures, including proposed legislation, needed to achieve the full economic benefits of metric usage.

Sec. 2. *Department and Agency Responsibilities.* All executive branch departments and agencies of the United States Government are directed to take all appropriate measures within their authority to carry out the provisions of this order. Consistent with this mission, the head of each executive department and agency shall:

(a) use, to the extent economically feasible by September 30, 1992, or such other date or dates established by the department or agency in consultation with the Secretary of Commerce, the metric system of measurement in Federal Government procurements, grants, and other business-related activi-

ties. Other business-related activities include all use of measurement units in agency programs and functions related to trade, industry, and commerce.

(1) Metric usage shall not be required to the extent that such use is impractical or is likely to cause significant inefficiencies or loss of markets to United States firms.

(2) Heads of departments and agencies shall establish an effective process for a policy-level and program-level review of proposed exceptions to metric usage. Appropriate information about exceptions granted shall be included in the agency annual report along with recommendations for actions to enable future metric usage.

(b) seek out ways to increase understanding of the metric system of measurement through educational information and guidance and in Government publications. The transition to use of metric units in Government publications should be made as publications are revised on normal schedules or new publications are developed, or as metric publications are required in support of metric usage pursuant to paragraph (a) of this section.

(c) seek the appropriate aid, assistance, and cooperation of other affected parties, including other Federal, State, and local agencies and the private sector, in implementing this order. Appropriate use shall be made of governmental, trade, professional, and private sector metric coordinating groups to secure the maximum benefits of this order through proper communication among affected sectors.

(d) formulate metric transition plans for the department or agency which shall incorporate the requirements of the Metric Conversion Act and this order, and which shall be approved by the department or agency head and be in effect by November 30, 1991. Copies of approved plans shall be forwarded to the Secretary of Commerce. Such metric transition plans shall specify, among other things:

(1) the total scope of the metric transition task for that department or agency, including firm dates for all metric accomplishment milestones for the current and subsequent fiscal years;

(2) plans of the department or agency for specific initiatives to enhance cooperation with industry, especially small business, as it voluntarily converts to the metric system, and with all affected parties in undertaking the requirements of paragraph (a) of this section; and

(3) specific steps and associated schedules through which the department or agency will seek to increase understanding of the metric system through educational information and guidance, and in department or agency publications.

(e) designate a senior-level official as the Metric Executive for the department or agency to assist the head of each executive department or agency in implementing this order. The responsibilities of the Metric Executive shall include, but not be limited to:

(1) acting as the department's or agency's policy-level representative to the ICMP and as a liaison with other government agencies and private sector groups;

(2) management oversight of department or agency outreach and response to inquiries and questions from affected parties during the transition to metric system usage; and

(3) management oversight of preparation of the department's or agency's metric transition plans and progress reports, including the Annual Metric Report required by 15 U.S.C. 205j and OMB Circular A-11.

(4) preparation by June 30, 1992, of an assessment of agency progress and problems, together with recommendations for steps to assure successful implementation of the Metric Conversion Act. The assessment and recommendations shall be approved by the head of the department or agency and provided

to the Secretary by June 30, 1992, for inclusion in the Secretary's October 1, 1992, report on implementation of this order.

Sec. 3. *Application of Resources.* The head of each executive department and agency shall be responsible for implementing and applying the necessary resources to accomplish the goals set forth in the Metric Conversion Act and this order.

Sec. 4. *Judicial Review.* This order is intended only to improve the internal management of the executive branch and is not intended to create any right or benefit, substantive or procedural, enforceable at law by a party against the United States, its agencies, its officers, or any other person.

THE WHITE HOUSE,
July 25, 1991.

[FR Doc. 91-18088
Filed 7-26-91; 2:08 pm]
Billing code 3195-01-M

VI. APPENDIX C: DESIGN REFERENCES AND RESOURCES

NAVFAC CONVERSION POLICY

NAVFAC METRICATION CONVERSION POLICY FOR DESIGN, PLANNING AND DESIGN CRITERIA, and NAVFAC GUIDE SPECIFICATIONS

TABLE OF CONTENTS

Policy.WP5

January 3, 1995

GENERAL POLICY

It is NAVFAC's policy to use the metric system of measurement (System International or SI) for planning and design criteria; Navy Facilities Guide Specifications; and construction contract documents for all MCON, BRACON, and family housing. The following guidelines should be adhered to when using metric units.

- Metric dimensions should be rounded to reflect required accuracy (e.g.: a BEQ module could be 6000 by 6200 mm).
- Select new rounded, rationalized metric products when available at a reasonable cost (e.g.: 1200 by 2400 mm drywall sheets).
- Value Engineering Team Studies (VETS) and Value Engineering Change Proposals (VECP) should not override the intent to use metric in Federal procurement.
- Calculations:
    - Calculations should be done in in-pound (IP) units when following inch-pound codes. Conversion to metric will be the final step.
    - If codes include metric units, calculations should be in metric.
- Cost estimates and Parametric Estimating and Programming (PEP): use metric (SI) units.
- Contract documents:
    - Contract documents should not contain dual units on the drawings or in the specifications.
    - Project specifications should contain a table relating familiar inch-pound products to the metric name for the product.
- All shop drawings should be in metric.
- To ensure facility maintainability, Operation and Maintenance Support Information (OMSI) is required on all metric projects. See NAVFAC guide Specification (NFGS) 01730.
- Metric (SI) units should be used from the planning stage through design and construction.

The January 1995 CCB will contain the inch-pound/metric NAVFAC Guide Specification database. Planning and design criteria will incorporate metric units as they are updated. Until the planning and design criteria is updated to include metric, the guidance contained in this policy should be followed.

BASIC METRIC TERMINOLOGY

- NOMINAL METRIC - an industry standard metric designation for existing products which had a nominal inch designation.

  Examples: 2 inch pipe becomes 50 mm pipe
  2 x 4 wood stud becomes 39 x 89 mm.

- NEW METRIC PRODUCT refers to an actual change in the product's size to new rounded rationalized metric dimensions. Initially, only modular products(brick, drywall, plywood, suspended ceiling components, floor tile, etc.) will change in size to match the 600 by 600 mm metric design planning grid (derived from the National Institute of Building Science's report of *Seven Metric Construction Case Studies*).

- OTHER METRIC DIMENSIONS

  - To convert properly, multiply the original value by the appropriate conversion factor. Round the resulting value to an appropriate number of significant digits without sacrificing or exaggerating the value desired. Do not round either the conversion factor or the value before performing the multiplication, as accuracy may be reduced (derived from ASTM E 621, *Standard Practice for Use of Metric (SI) Units in Building Design and Construction).* The American Institute of Architects *Weights and Measures Policies,* Appendix A *Weights and Measures Conversion Tables* will give the agreed upon conversion factors.

  - Professional judgment must rule in deciding how to round a specific dimension. Original inch-pound numbers should be carefully evaluated to determine the figure's intended accuracy before selecting a rounding strategy. The following guidelines are suggested for use in Navy planning, design, and construction projects.

LINEAR MEASUREMENT

ROUNDING TO THE NEAREST	IMPLIES A NEEDED ACCURACY OF
1 mm	1/32 in
3 mm	1/8 in
5 mm	3/16 in
10 mm	3/8 in
25 mm	1 in
100 mm	4 in
1000 mm OR 1 m	3 ft
0.1 km	300 ft
1 km	1/2 mi

AREA MEASUREMENT

ROUNDING TO THE NEAREST	IMPLIES A NEEDED ACCURACY OF
0.1 sq. m.	1 sq. ft.
1.0 sq. m.	10 sq. ft.
1 ha	2.5 AC
1 sq. km.	250 AC or 0.5 sq. mi.

GENERAL NAVFAC METRICATION PRINCIPLES AND GUIDELINES

- Use this document in conjunction with the American Institute of Architects (AIA) "Weights and Measures Style Guide for Masterspec" and GSA Region 3's M2 publication. If discrepancies occur between documents, this order of precedence is:

    1. This NAVFAC Policy Document
       Source: EFD's and EFA's

    2. AIA Weights and Measures Style Guide for Masterspec
       Source:
       Tel: (202) 626-7352
       or
       Tel: (202) 626-7387

    3. GSA Region 3's M2 publication
       Source:
       Tel: (215) 656-5822
       also available on CCB

- Most building products (90 - 95%) have not or will not change in actual size for the conversion to metric. These products simply are or will be relabeled in metric units and therefore product availability is not a significant problem. Some of these products that have to be relabeled or renamed will require a consensus among industry members. Checking at the specification, basis of design, and PEP stages to ensure that the metric products to be specified are readily available is the best way to prevent subsequent problems.

- The remaining 5 - 10% of the building products are or will have to be manufactured in a new metric size. Use new rounded rational metric materials and products unless they are not economically available or will not integrate into the building system with non metric products. The majority of these products will have to be manufactured to conform to the 600 by 600 mm metric planning grid that has been adopted by the construction industry. Products that fit the 600 by 600 mm grid are often referred to as "hard metric." For most of these rounded rational metric products the thickness will not change so that fire, acoustic, and thermal ratings will not have to be recalculated or retested. Examples of these products are drywall, fire doors, fire rated ceiling tile, and acoustically rated partitions.

- To control project costs the designer should select high volume, commonly used building products that are currently manufactured in rounded rational metric sizes and generally available, see GSA Region 3's M2 publication or U.S. Metric

Association's *Metric Source Vendor List*[*]. The experience of other agencies with metric construction suggests that most of the problems encountered in the transition to metric are in nomenclature and that we must be clear in our communication with the contractor. Tools such as pre-design, partnerings pre-bid, and pre-construction conferences may help clarify our intent.

- SI units should be used from the planning stages through design, construction, and maintenance. Where local permits are required from the local governing authority, acceptability of metric drawings and calculations by the governing authority should be verified. NAVFAC design criteria will be available in metric in the near future. NAVFAC Metric Guide Specifications are currently available as a separate database on the CCB. The Metric guide specifications will be combined with the current inch-pound guide specifications to form one set of metric/inch-pound guide specifications for the January release of the CCB. The NAVFAC Metric Guide Specifications should be used on all projects. All contractor and subcontractor submittals (shop drawings, certificates, test data and reports) should be in SI units.

- Design professionals must apply common sense and professional judgment to convert U.S. Customary (IP) units to metric (SI) units. Not all conversions are logical or intuitive. Converted values should be rounded to the proper number of significant digits commensurate with the intended accuracy. The practical aspects of measuring must be considered when using SI equivalents. Generally, use rounded rationalized SI units if the product is available. ASTM E 380, *Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)*, Article 5.2 explains and gives guidelines for rounding and accuracy.

- The American Institute of Architects *Weights and Measures Policies*, Appendix B *Construction Products* gives the agreed upon material and product subjects with IP and SI notations. This publication is scheduled for publication towards the end of 1994.

[*] Available from
U.S. Metric Association (USMA)
10245 Andasol Ave.
Northridge, CA 91325-1505
Tel/Fax (818) 368-7443

ALL DISCIPLINES

- Dual units (both inch-pound and metric) should not be used on drawings. It increases dimensioning time, doubles the chance for errors, makes drawings more confusing, and delays the learning process.

- Do not use dual units in specifications. All unit conversions should be checked to ensure that rounding does not exceed allowable tolerances.

- Where new rounded rational metric products are available, the actual metric dimensions will be used.

- Where new rounded rational metric products are not available, the nominal IP dimensions will be mathematically converted using an industry preferred metric nominal dimension when available.

- Upon preparation of a new metric specification, manufacturers, governing bodies, and associations/organizations governing the product will be contacted for their input and review.

- To aid the guide specification user, a "Technical note" will be included at the end of each guide specification identifying products specified in the section that are known to be available in true metric dimension at the time of the last guide specification revision.

- There are seven metric base units of measurement, six of which are used in design and construction. The seventh, mole, is the amount of molecular substance and is used in physics. The six base units used in design and construction are:

Quantity	Unit (Symbol)	
length	meter (m)	
mass	kilogram (kg)	Note that "weight" in common practice often is used to mean "mass."
time	second (s)	
electric current	ampere (A)	
luminous intensity	candela (cd)	
temperature	celsius (C)	Celsius temperature is more commonly used than kelvin but both have the same temperature gradients. To move between Celsius and kelvin, add or subtract 273.15.

- Centimeters should not be used in construction.

- Do not use exponents to indicate the word square or cubic. Use the abbreviations (sq. or cu.) in formulas or numeric expressions.

  Example Use 36 sq. m. not 36 m^2
  Use 36 cu. m. not 36 m^3

- The basic metric module is 100 mm. Submodules in preferred order are 50 mm , 25 mm, 20 mm, 10 mm, and 5 mm. Multimodules in preferred order are 300 mm, 600 mm, 3000 mm, and 6000 mm. For buildings, the metric planning grid is usually 600 mm.

- For survey measurement, use kilometer and meter. For site drawings, use meter and millimeter. For building construction drawings, use millimeters.

- Metric scales are true ratios and are the same for both architectural and engineering drawings. Preferred scales are:

1:1	Same as full size
1:5	Close to 3" = 1'-0"
1:10	Between 1" = 1'-0" and 1-1/2" = 1'-0"
1:20	Between 1/2" = 1'-0" and 3/4" = 1'-0"
1:50	Close to 1/4" = 1'-0"
1:100	Close to 1/8" = 1'-0"
1:200	Close to 1/16" = 1'-0"
1:300	Close to 1" = 25'-0"
1:500	Close to 1" = 40'-0"
1:1000	Close to 1" = 80'-0"

- Drawings

  - What will change:

    Units - from feet and inches to millimeters for all building dimensions and to meters for large site plans and civil engineering drawings. Meters are normally carried to one, two, or three decimal places.

    When denoting nondimensional slope ratios, the first digit is the vertical unit and the second digit is the horizontal unit. When the angle is less than 45 deg., the vertical component should be unitary (e.g. 1:10). When the angle is greater than 45 deg., the horizontal component should be unitary (e.g. 5:1).

    Drawing scales - from inch-fractions-to-feet (e.g. 1/2" = 1'-0") to true ratios (e.g. 1:20)

Drawing sizes - to the ISO "A" series as follows:

A0 - 1189 x 841 mm (46.8 x 33.1 inches)
A1 - 841 x 594 mm (33.1 x 23.4 inches)
A2 - 594 x 420 mm (23.4 x 16.5 inches)
A3 - 420 x 297 mm (16.5 x 11.7 inches)
A4 - 297 x 210 mm (11.7 x 8.3 inches)

NOTE: Continue to use IP sheets (D-size, F-size, etc.) until supplies are exhausted, at which time International Organization for Standardization (ISO) "A" series drawing sheets (A1, etc.) should be used. Use the minimum lettering height that is legible taking into consideration that the drawing may be reduced to half size during the printing process.

- What will stay the same

  Drawing contents

- Specifications
  - What will change:

    Units of measure - inch-pound units to metric units.

    Reference documents - Various organizations have developed or are developing separate specifications for metric products.

  - What will stay the same:

    Everything else.

- Planning and Design Criteria (including family housing)
  - Metric will be included as criteria are updated. Criteria may be metric only or metric will be listed as the primary unit of measurement with inch-pound designation as secondary.

SPECIFIC DISCIPLINES

Guidelines to Architectural/Engineering disciplines are contained in the following sections. These sheets list the exceptions to the AIA metric publication. Addresses, telephone numbers, and FAX numbers for the various organizations listed in the following discipline unique sheets may be found in NFGS 01090.

CIVIL ENGINEERING

EXCEPTIONS AND ADDITIONS TO THE GENERAL GUIDELINES:

- Unit designations and conversions will be in accordance with ASTM E621-84 (R 1991) as modified by the "Metric Guide for Federal Construction", First Edition.

- All piping, valves, conduits, tubing, and associated fittings will be U.S. industry standards, designated by nominal diameter equivalent. Sizes will not change by switching to the metric system as U.S. sizes are used in many parts of the world.

- Concrete strength will be in megapascals (MPa) and reinforcement will be in grades 300 and 400 MPa yield strength.

- Celsius will be used for the metric equivalent of Fahrenheit.

CODES, STANDARDS, PROFESSIONAL AND TRADE ORGANIZATIONS

The following is a listing of metric notes from various associations and organizations dealing with building products. If you have any additional information that pertains to metric products, please contact the NAVFAC Guide Specifications Division.

American Association of State Highway Transportation Officials (AASHTO)

In June 1993, AASHTO published the *Guide to Metric Conversion* for use by states in meeting the Federal Highway Administration's (FHWA) mandate that all federally aided highway projects after October 1996 be built in metric. An AASHTO metric task force is establishing a metric information clearinghouse to help the states set uniform metric procedures and standards. For Class A structures, ASSHTO will be publishing an SI version of the *Standard Specification for Highway Bridges* in 1995.

American Concrete Institute (ACI)

Two of ACI's principle publications, *Building Code Requirements for Reinforced Concrete* (ACI-318M) and *Building Code Requirements for Plain Concrete* (ACI-318.1M) are available in metric editions. ACI is considering a timetable for converting its remaining documents to hard metric as early as 1998.

American Concrete Pipe Association (ACPA)

Currently there are 22 ASTM standards on concrete pipe that have been issued in metric units. ACPA is revising it's design manuals, handbooks, software, and marketing materials to include metric by 1996. Concrete pipe is classified by the nominal mm size (ASTM C76/C76M).

American Institute of Steel Construction (AISC)

AISC recently published the *Metric Properties of Structural Steel Shapes with Dimensions According to ASTM A6M.* A complete metric edition of the *LRFD Manual of Steel Construction* is available. AISC is working with the Industrial Fasteners Institute to develop a policy on the metrication of structural steel bolts. High strength bolts are currently available in metric sizes (ASTM A325M and ASTM A490M).

American Iron and Steel Institute (AISI)

Basic steel mill products are available today in metric sizes and voluntary consensus standards for these products are available through ASTM and other organizations. AISI is developing metric engineering aids for steel bridge design as well as adding metric units to its design manual for cold formed steel structures.

American National Standards Institute (ANSI)

In October, 1993, ANSI adopted a policy stating that units of the modernized metric system (SI) are the preferred units of measurement in American National Standards. To facilitate implementation of this policy, ANSI has formed a task group on metrication to encourage and assist ANSI member organizations in converting their standards to metric.

American Society of Civil Engineers (ASCE)

Since 1993, ASCE has mandated that metric be included as the primary unit in all new and revised standards with no other units being required.

American Society of Mechanical Engineers (ASME)

All ASME standards contain metric units except the *Boiler and Pressure Vessel Code*, which is being converted now. ASME has set a target date of 1998 for the publication of its codes and standards only in metric.

American Society for Testing and Materials (ASTM)

ASTM requires the use of metric in all of its standards. Approximately 1600 ASTM standards use only metric units, 3500 use metric as the primary unit, and the remaining 3000 use metric as the secondary unit. Recently, ASTM and the Institute of Electrical and Electronics Engineers (IEEE) have begun negotiations to merge their two metric standards, ASTM E380-93, *Standard Practice for the Use of International Units,* and ANSI/IEEE 268, *American National Standard Metric Practice.*

American Water Works Association (AWWA)

AWWA has undertaken a program to convert its publications and other documents to metric by January 1997. Metric units have been added to many of AWWA's 120 water supply product and procedural standards.

National Electrical Manufacturers Association (NEMA)

NEMA Code and Standards has approved metric designations for rigid steel conduit (GRC), intermediate metal conduit (IMC), and electrical metallic tubing (EMT). Metric designations are for trade sizes from 1/2 inch (16 mm) to 6 inches (155 mm).

National Fire Protection Association (NFPA)

NFPA codes and standards include metric units. Converting measurements to hard metric will require the submittal of proposals through the standards-making process.

Precast/Prestressed Concrete Institute (PCI)

PCI supports the FHWA's metric conversion policy as it applies to precast/prestressed concrete bridge products. PCI advocates an initial soft conversion by rounding all dimensions to the nearest 5 mm, followed over time by hard conversion. All new PCI publications include metric units and a metric edition of PCI's *Design Handbook* is being considered for publication in 1996.

NAVFAC Point of Contact:

NCBC
Guide Specifications Department, NAVFAC 15G
1000 23RD Ave.
Port Hueneme, CA 93043-4301
Telephone: (805) 982-5465
FAX (805) 982-5196

ARCHITECTURAL

EXCEPTIONS AND ADDITIONS TO THE GENERAL GUIDELINES:

- Where hard metric products are not available, the dimensions will be converted to "soft and exact" dimensions in accordance with ASTM E380 (for example, 15.9 mm for 5/8 inch thick drywall).

- Where nominal dimensions will be used, the conversion will be to "soft and nominal" dimensions (for example, 300 mm for 12 inches).

CODES, STANDARDS, PROFESSIONAL AND TRADE ORGANIZATIONS

The following is a listing of metric notes from various associations and organizations dealing with building products. If you have any additional information that pertains to metric products, please contact the NAVFAC Guide Specifications Division.

American Forest and Paper Association (AFPA)

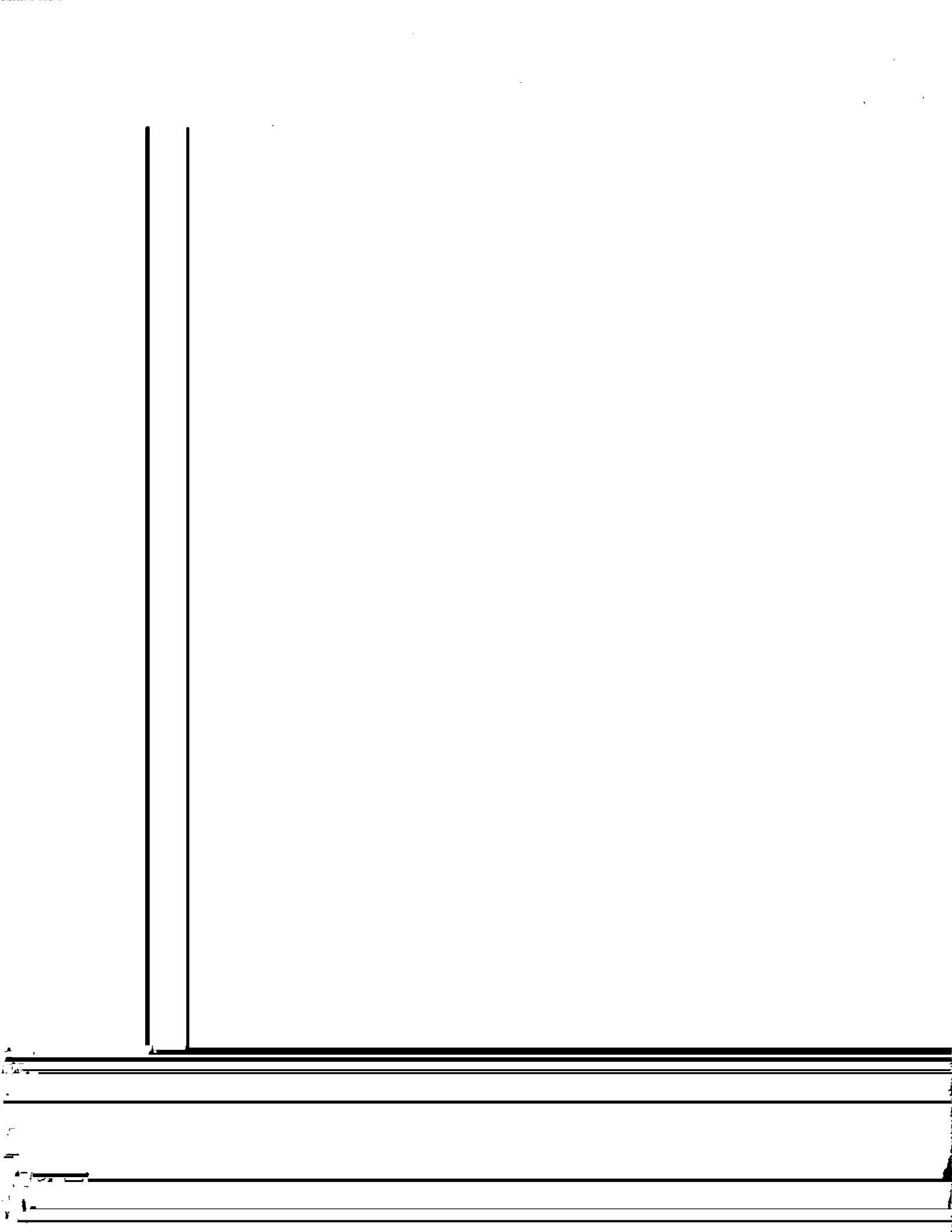
AFPA is about to issue a new edition of the *Metric Planning Package for the Wood Products Industry.* It includes industry recommendations for metric conversion. The upcoming 1996 edition of the *National Design Specification for Wood Construction* will include metric units as will the *LRFD for Engineered Wood Construction.*

American Institute of Steel Construction (AISC)

AISC recently published the *Metric Properties of Structural Steel Shapes with Dimensions According to ASTM A6M.* A complete metric edition of the *LRFD Manual of Steel Construction* is available. AISC is working with the Industrial Fasteners Institute to develop a policy on the metrication of structural steel bolts. High strength bolts are currently available in metric sizes (ASTM A325M and ASTM A490M).

American Iron and Steel Institute (AISI)

Basic steel mill products are available today in metric sizes and voluntary consensus standards for these products are available through ASTM and other organizations. AISI is developing metric engineering aids for steel bridge design as well as adding metric units to its design manual for cold formed steel structures.



Gypsum Association

The Gypsum Association has no policy on metrication but notes that many of its member manufacturers can produce panels in hard metric sizes (other than thickness which will remain the same due to fire ratings). ASTM C36-93 includes metric thickness in parentheses. The following sizes are given in ASTM C36-93:

1/4 inch	6.4 mm
5/16 inch	8 mm
3/8 inch	9.5 mm
1/2 inch	12.7 mm
5/8 inch	15.9 mm

Hardwood Plywood and Veneer Association (HPVA)

Last year, HPVA revised its *Interim Voluntary Standard for Hardwood and Decorative Plywood* to include metric units. Currently it is adding metric to its other two standards, ANSI/HPMA LHF, *American National Standard for Laminated Hardwood Flooring,* and DFV-1 *Voluntary Standard for Sliced Decorative Wood Face Veneer.*

Kitchen Cabinet Manufacturers Association (KCMA)

KCMA's standard, ANSI/KCMA A161.1, *Recommended Performance & Construction Standards for Kitchen and Vanity Cabinets,* includes metric units.

National Association of Architectural Metal Manufacturers (NAAMM)

NAAMM is adding metric units to its standards.

National Electrical Manufacturers Association (NEMA)

NEMA Code and Standards has approved metric designations for rigid steel conduit (GRC), intermediate metal conduit (IMC), and electrical metallic tubing (EMT). Metric designations are for trade sizes from 1/2 inch (16 mm) to 6 inches (155 mm).

National Fire Protection Association (NFPA)

NFPA codes and standards include metric units. Converting measurements to hard metric will require the submittal of proposals through the standards-making process.

National Roofing Contractors Association (NRCA)

NRCA has approved a policy to support metric conversion in the roofing industry and to implement the use of metric units in all NRCA publications, manuals, programs, research, and instructional materials.

Uniform Building Code (UBC)

The 1994 edition of the Uniform Building, Fire, Mechanical, and Plumbing codes was published with dual units (IP & SI).

NAVFAC Point of Contact:

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1000 23RD Ave.
Port Hueneme, CA 93043-4301
Telephone: (805) 982-6087
FAX (805) 982-5196

STRUCTURAL ENGINEERING

EXCEPTIONS AND ADDITIONS TO THE GENERAL GUIDELINES:

- All calculations should be made using SI units. However, until industry standards are converted, IP units may be used with final answers converted to SI. Determine field dimensions using SI units to avoid conversion errors. Convert existing documented IP dimensions, information, and equations to metric units if feasible and where no SI equivalent exists. Some empirical equations are IP unit dependent and cannot be easily converted to SI unless one knows the derivation. Obviously, they may remain unconverted. Convert input and output data accordingly. The preferred units for structural engineering are:

Dimension	U.S. Customary (IP)	Metric (SI)
Angle	degrees (deg)	radians (rad) or degrees (deg)
Density	pound/cu foot (pcf)	kilogram/cu meter (kg/cu m)
Force	pound (lb)	newton (N)
	Kip (1000 lb)	kilonewton (kN)
	Ton (2000 lb)	kilonewton (kN)
Linear dimensions	Feet (ft), yard (yd), inches (in)	millimeter (mm)
Mass	pound (lb)	kilogram (kg)
Moment/torque	foot-kips (ft-kips)	kilonewton-meter (kNm)
	foot pounds (ft-lb)	newton-meter (Nm)
Pressure	pound/square foot (psf)	kilopascal (kPa)
Slope	dimensional ratio	nondimensional ratio
Stress	pound/square inch (psi)	megapascal (MPa)
Temperature	fahrenheit (deg F)	celsius (deg C)
Thickness	gage (g)	millimeter (mm)
Velocity	miles/hour (mph)	meter/second (m/s)
	feet/second	meter/second (m/s)

- Convert design loads in the Building Codes and Mil-Hdbks from IP to SI units until criteria is converted to hard metric. Express capacity in kPa. Express capacity of existing areas to the nearest one-tenth kPa (e.g. 3.6 kPa). Design and detail new areas to the nearest kPa (e.g. 4.0 kPa). Base seismic analysis and blast analysis on NAVFAC P-355 and DM 2.08 respectively using IP units. Convert calculated loads to SI units before design.

- The AISC/ASD Manual will not be published in SI units.

- Metric steel yield points are available and noted in ASTM A36M, A572M, and A588M.

- Denote welds in even sizes (e.g. 5 mm, 6 mm, etc.)

- Mortar and grout strengths will be given in SI units.

- Floor Loads

  - What will change:

    Floor load designations - from "psi" to kilograms per square meter (kg/sq. m) or kilonewtons per square meter (kN/sq. m)

  - What will stay the same:

    Floor load requirements

    NOTE: In common practice, kilograms per square meter are used for floor loads because many live and dead loads are measured in kilograms. However, kilonewtons per square meter or the equivalent megapascals are used for structural calculations.

CODES, STANDARDS, PROFESSIONAL AND TRADE ORGANIZATIONS

The following is a listing of metric notes from various associations and organizations dealing with building products. If you have any additional information that pertains to metric products, please contact the NAVFAC Guide Specifications Division.

American Association of State Highway Transportation Officials (AASHTO)

In June 1993, AASHTO published the *Guide to Metric Conversion* for use by states in meeting the Federal Highway Administration's (FHWA) mandate that all federally aided highway projects after October 1996 be built in metric. An AASHTO metric task force is establishing a metric information clearinghouse to help the states set uniform metric procedures and standards. For Class A structures, ASSHTO will be publishing an SI version of the *Standard Specification for Highway Bridges* in 1995.

American Concrete Institute (ACI)

Two of ACI's principle publications, *Building Code Requirements for Reinforced Concrete* (ACI-318M) and *Building Code Requirements for Plain Concrete* (ACI-318.1M) are available in metric editions. ACI is considering a timetable for converting its remaining documents to hard metric as early as 1998.

American Institute for Hollow Structural Sections (AIHSS)

AIHSS recently completed two guides, *Summary of Presentation Factors and Procedures for Determining Properties of Square and Rectangular HSS/Structural Steel Tubing from U.S. Customary Units to Metric Units* and *Recommendations for Soft Conversion of Dimensions of Square, Rectangular, and Round HSS/Structural Steel Tubing from U.S. Customary Units to Metric Units.*

American Institute of Steel Construction (AISC)

AISC recently published the *Metric Properties of Structural Steel Shapes with Dimensions According to ASTM A6M.* A complete metric edition of the *LRFD Manual of Steel Construction* is available. AISC is working with the Industrial Fasteners Institute to develop a policy on the metrication of structural steel bolts. High strength bolts are currently available in metric sizes (ASTM A325M and ASTM A490M).

American Iron and Steel Institute (AISI)

Basic steel mill products are available today in metric sizes and voluntary consensus standards for these products are available through ASTM and other organizations. AISI is developing metric engineering aids for steel bridge design as well as adding metric units to its design manual for cold formed steel structures.

American National Standards Institute (ANSI)

In October, 1993, ANSI adopted a policy stating that units of the modernized metric system (SI) are the preferred units of measurement in American National Standards. To facilitate implementation of this policy, ANSI has formed a task group on metrication to encourage and assist ANSI member organizations in converting their standards to metric.

American Plywood Association (APA)

The APA is not setting any metric size designations for plywood but is recommending soft conversion of inch-pound sizes. They indicate that once metric usage is more widespread, true metric sizes may be established.

American Society of Civil Engineers (ASCE)

Since 1993, ASCE has mandated that metric be included as the primary unit in all new and revised standards with no other units being required.

American Society for Testing and Materials (ASTM)

ASTM requires the use of metric in all of its standards. Approximately 1600 ASTM standards use only metric units, 3500 use metric as the primary unit, and the remaining 3000 use metric as the secondary unit. Recently, ASTM and the Institute of Electrical and Electronics Engineers (IEEE) have begun negotiations to merge their two metric standards, ASTM E380-93, *Standard Practice for the Use of International Units*, and ANSI/IEEE 268, *American National Standard Metric Practice*.

American Water Works Association (AWWA)

AWWA has undertaken a program to convert its publications and other documents to metric by January 1997. Metric units have been added to many of AWWA's 120 water supply product and procedural standards.

Architectural Precast Association (APA)

APA supports the Precast/Prestressed Concrete Institute's recommendations on metric conversion.

Building Officials and Code Administrators International (BOCA)

BOCA National Building, Fire Prevention, Mechanical, and Plumbing Codes are all published with dual units (IP & SI).

Brick Institute of America (BIA)

BIA has adopted a metric policy stating that it; (1) supports conversion to metric units of measure as an inevitable action; (2) will continue to provide information in both metric and inch-pound units, as it has since 1978; (3) encourages all brick manufacturers and distributors to publish their product literature and other

design data in equivalent metric versions or with both metric and inch-pound units; (4) will work with brick manufacturers to promote the use and manufacturer of modular metric sizes through its technical marketing, and informational publications; (5) will continue to work with the Federal Government and within the codes and standards organizations to provide masonry, standards, and specifications in correct metric units; and (6) encourages the training of bricklayers in vocational programs in the use of the metric system as it relates to brick masonry. In addition, BIA anticipates the publication of a new *Technical Notes* on modular metric brick.

Metric brick is currently available, 190 by 57 by 90 mm using a 10 mm joint and forming a 600 mm by 600 mm module (from Tech Notes 10B).

Concrete Reinforcing Steel Institute (CRSI)

CRSI has initiated the development of several metric design and detailing aids including printed metric bar cards and a computer program, DEVLAPM, for determining development and lap splice lengths for metric reinforcing bars. Metric versions of a wall bar chart will be completed by the end of 1993 and a metric version of the CRSI *Manual of Standard Practice* is being prepared. CRSI began converting its other technical publications and design aids in 1994. Concrete rebar and welded wire fabric is currently manufactured and available in metric sizes.

Council of American Building Officials (CABO)

CABO is made up of the three model code organizations; BOCA, SBCCI, and ICBO. The BOCA *National Codes* have included metric units since 1975. SBCCI added metric units to its *Standard Building Code* in 1991 and added metric to the balance of its Codes in 1994. ICBO added metric units to its *Uniform Building Codes* in 1994. Metric will be added to the CABO *One and Two-Family Dwelling code* in 1995. CABO is secretariat to the ANSI A117.1 accessibility code, which has contained metric units since its inception.

National Association of Architectural Metal Manufacturers (NAAMM)

NAAMM is adding metric units to its standards.

National Particleboard Association (NPA)

NPA recently issued a revised version of its standard, ANSI A208.1-1993, *Particleboard,* in hard metric. During the conversion process, the number of particleboard grades was reduced from 19 to 12.

Precast/Prestressed Concrete Institute (PCI)

PCI supports the FHWA's metric conversion policy as it applies to precast/prestressed concrete bridge products. PCI advocates an initial soft conversion by rounding all dimensions to the nearest 5 mm, followed over time by hard conversion. All new PCI publications include metric units and a metric edition of PCI's *Design Handbook* is being considered for publication in 1996.

Steel Deck Institute (SDI)

The Steel Deck Institute has not set any metric sizes and does not indicate any plans to do so in the near future. while metal thickness can easily be changed if metric sized sheet metal becomes available, changing deck patterns means replacing rollers, and will probably not occur as soon.

Southern Building Code Congress International (SBCCI)

The 1991 edition of the *Standard Building Code* is published with dual units (IP & SI). The Standard Fire, Plumbing, and Mechanical Codes was published with dual units late in 1994.

Steel Joist Institute (SJI)

SJI indicated that specifications for steel joist with metric units are now available.

Uniform Building Code (UBC)

The 1994 edition of the Uniform Building, Fire, Mechanical, and Plumbing codes was published with dual units (IP & SI).

NAVFAC Point of Contact:

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FAX (805) 982-5196

MECHANICAL ENGINEERING

EXCEPTIONS AND ADDITIONS TO THE GENERAL GUIDELINES:

- Conversions will be done in accordance with ASTM E380-91A "Use of International System of Units (SI) (The Modernized System)" and in accordance with ASHRAE Handbook of Fundamentals, 1993 Chapter 35.

- Field dimensions will be directly converted to soft and nominal metric dimensions.

- All piping, pipe fittings, and valves are classified by the new nominal millimeter size as shown on the attached table. Schedule designations (Schedule 40, Type K, L, M, etc.) and piping system classes will remain the same.

- Rectangular metal ductwork will be specified in rounded millimeter size designations, flexible round duct will be in soft converted sizes, diffusers and registers will be in hard converted sizes, sheetmetal thickness in gages, and HVAC control equipment in Celsius temperature.

- Unit of power for electrical motors (pumps, fans, etc.) will be in KW.

RECOMMENDED NOMINAL METRIC SIZES FOR PIPE PRODUCTS

NPS (inches)	DN (mm)	NPS (inches)	DN (mm)
1/8	6	8	200
3/16	7	10	250
1/4	8	12	300
3/8	10	14	350
1/2	15	16	400
5/8	18	18	450
3/4	20	20	500
1	25	24	600
1 1/4	32	28	700
1 1/2	40	30	750
2	50	32	800
2 1/2	65	36	900
3	80	40	1000
3 1/2	90	44	1100
4	100	48	1200
4 1/2	115	52	1300
5	125	56	1400
6	150	60	1500

For pipe over 60 inches, use 1 inch equals 25 mm
NPS is the inch-pound designation for "Nominal Pipe Size"
DN is the metric designation for "Diameter Nominal"

Source: Construction Metrication Council, National Institute of Building Sciences, August 1993

CODES, STANDARDS, PROFESSIONAL AND TRADE ORGANIZATIONS

The following is a listing of metric notes from various associations and organizations dealing with building products. If you have any additional information that pertains to metric products, please contact the NAVFAC Guide Specifications Division.

Air-Conditioning and Refrigeration Institute (ARI)

ARI's metric policy states that each ARI section is to adopt an international standard within one year of the publication. To assist in this process, ARI has issued a new guidance document, *Use of SI Units in ARI Standards.*

American Iron and Steel Institute (AISI)

Basic steel mill products are available today in metric sizes and voluntary consensus standards for these products are available through ASTM and other organizations. AISI is developing metric engineering aids for steel bridge design as well as adding metric units to its design manual for cold formed steel structures.

American National Standards Institute (ANSI)

In October, 1993, ANSI adopted a policy stating that units of the modernized metric system (SI) are the preferred units of measurement in American National Standards. To facilitate implementation of this policy, ANSI has formed a task group on metrication to encourage and assist ANSI member organizations in converting their standards to metric.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

ASHRAE's four handbooks are available in both inch-pound and metric editions. ASHRAE's strategic plan states that ASHRAE will implement a policy and promote utilization of metric units by the HVAC&R and allied industries, develop and implement a plan that will promote and assist the HVAC&R and allied industries in implementing the use of metric units by the year 2000, and to develop and implement a plan to use only metric units in ASHRAE publications by the year 2000.

American Society of Mechanical Engineers (ASME)

All ASME standards contain metric units except the *Boiler and Pressure Vessel Code*, which is being converted now. ASME has set a target date of 1998 for the publication of its codes and standards only in metric.

American Society for Testing and Materials (ASTM)

ASTM requires the use of metric in all of its standards. Approximately 1600 ASTM standards use only metric units, 3500 use metric as the primary unit, and the remaining 3000 use metric as the secondary unit. Recently, ASTM and the Institute of Electrical and Electronics Engineers (IEEE) have begun negotiations to merge their two metric standards, ASTM E380-93, *Standard Practice for the Use of International Units*, and ANSI/IEEE 268, *American National Standard Metric Practice*.

American Water Works Association (AWWA)_

AWWA has undertaken a program to convert its publications and other documents to metric by January 1997. Metric units have been added to many of AWWA's 120 water supply product and procedural standards.

Building Officials and Code Administrators International (BOCA)

BOCA National Building, Fire Prevention, Mechanical, and Plumbing Codes are all published with dual units (IP & SI).

Council of American Building Officials (CABO)

CABO is made up of the three model code organizations; BOCA, SBCCI, and ICBO. The BOCA *National Codes* have included metric units since 1975. SBCCI added metric units to its *Standard Building Code* in 1991 and will add them to the balance of its Codes in 1994. ICBO will add metric units to its *Uniform Building Codes* in 1994. Metric will be added to the CABO *One and Two-Family Dwelling code* in 1995. CABO is secretariat to the ANSI A117.1 accessibility code, which has contained metric units since its inception.

Instrument Society of America (ISA)

ISA produces instrument and control systems standards for the HVAC and industrial process industries in the United States and abroad. All new and recently revised ISA standards express measurements in metric units.

International Association of Plumbing and Mechanical Officials (IAPMO)

IAPMO is incorporating metric units in its standards and other publications and has added metric to the 1994 edition of its plumbing code, published by ICBO as the *Uniform Plumbing Code*.

National Fire Protection Association (NFPA)

NFPA codes and standards include metric units. Converting measurements to hard metric will require the submittal of proposals through the standards-making process.

Southern Building Code Congress International (SBCCI)

The 1991 edition of the *Standard Building Code* is published with dual units (IP & SI). The Standard Fire, Plumbing, and Mechanical Codes was published with dual units late in 1994.

Uniform Building Code (UBC)

The 1994 edition of the Uniform Building, Fire, Mechanical, and Plumbing codes was published with dual units (IP & SI).

NAVFAC Point of Contact:

NCBC
Guide Specifications Department, NAVFAC 15G
1000 23RD Ave.
Port Hueneme, CA 93043-4301
Telephone: (805) 982-5743
FAX (805) 982-5196

ELECTRICAL ENGINEERING

EXCEPTIONS AND ADDITIONS TO THE GENERAL GUIDELINES:

- Conductor sizes shown in AWG will not be given an SI equivalent and will remain AWG.

- Conduit sizes will be in SI units in accordance with the metric designation being developed by NEMA. This applies to rigid steel conduit and electrical metallic tubing. Non-metallic conduit will remain converted to metric until a standard is developed.

CODES, STANDARDS, PROFESSIONAL AND TRADE ORGANIZATIONS

The following is a listing of metric notes from various associations and organizations dealing with building products. If you have any additional information that pertains to metric products, please contact the NAVFAC Guide Specifications Division.

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National Electrical Manufacturers Association (NEMA)

NEMA Code and Standards has approved metric designations for rigid steel conduit (GRC), intermediate metal conduit (IMC), and electrical metallic tubing (EMT). Metric designations are for trade sizes from 1/2 inch (16 mm) to 6 inches (155 mm).

National Fire Protection Association (NFPA)

NFPA codes and standards include metric units. Converting measurements to hard metric will require the submittal of proposals through the standards-making process.

Uniform Building Code (UBC)

The 1994 edition of the Uniform Building, Fire, Mechanical, and Plumbing codes was published with dual units (IP & SI).

NAVFAC Point of Contact:

NCBC
Guide Specifications Department, NAVFAC 15G
1000 23RD Ave.
Port Hueneme, CA 93043-4301
Telephone: (805) 982-5458
FAX (805) 982-5196

PLANNING AND PROGRAMMING

EXCEPTIONS AND ADDITIONS TO THE GENERAL GUIDELINES:

- To accommodate 2 position unit of measure fields in the Shore Facilities Planning System (SFPS) and Military Construction Programming (MCP) system data bases it is necessary to deviate from AIA's units of measures.

GUIDANCE FOR SFPS AND MCP

Existing System		Metric System		
Unit of Measur	UM	Unit of Measure	UM	Conversion Factor
Acres	AC	Hectares	ha	0.404 687 30
Barrels	BL	Cubic Meters	m3	0.158 987 30
Cubic Feet	CF	Cubic Meters	m3	0.028 316 85
CF/Minute	CM	Meters^3 per minute	cM	0.028 316 85
Candle Power	CP	Candela	cd	1.000 000 00
Cubic Yards	CY	Cubic Meters	m3	0.764 554 90
Depth water over sill	DS	Depth of water over sill	ds	0.304 800 00
Depth water low tide	DW	Depth of water low tide	dw	0.304 800 00
Feet of Berthing	FB	Meters of berthing	mB	0.304 800 00
Gallons	GA	Liters	L	3.785 412 00
Gallons per minute	GM	Liters per minute	LM	3.785 412 00
1000's gallons per day	KG	1000's Liters per Day	kD	3.785 412 00
kilo volt-amperes	KV	Kilowatts	kw	1.000 000 00
Kilowatts	KW	Kilowatts	kw	1.000 000 00
Linear Feet	LF	Meters	m	0.304 800 00
Millions BTU/hr	MB	Megawatts	Mw	0.293 071 10
Meters	ME	Meters	m	1.000 000 00
Millions of Gallons	MG	Megaliters	ML	3.785 412 00
Statute Miles	MI	Kilometers	km	1.609 347 00
Net square feet housing	NF	Net Square Meters	Nm	0.092 903 04
Net square feet storage	NS	Net Square Meters	Nm	0.092 903 04
Pounds per Hour	PH	Kilograms per Hour	kH	0.453 592 37
Square Feet	SF	Square Meters	m2	0.092 903 04
Stacking Height	SH	Meters	m	0.304 800 00
Square Yards	SY	Square Meters	m2	0.836 127 40
Total Cubic Feet	TC	Cubic Meters	m3	0.028 316 85
Tons Per Hour	TH	Metric Tons per Hour	tH	0.907 184 74
Tons (refrigeration)	TN	Kilowatts	kw	3.516 800 00
Tons (weight)	TN	Metric Tons	t	0.907 184 74

There are several other existing units of measure that are not affected by the transition to the metric system. These will each have the same metric unit of measure that they had with the existing system. They include: Hospital bed, normal (BD); Boxes, fire alarm (BX); Each (EA); Family units, housing (FA); Firing Point (FP); Holes, golf course (HO); Lanes, bowling (LN); Light care hospital beds (LC); Outlets (OL); Operating units (OU); Persons (PN); Seats (SE); Sites (SI); Service Points (SP); and Vehicles (VE).

ADDITIONAL CODES, STANDARDS, PROFESSIONAL AND TRADE ORGANIZATIONS

American Congress on Surveying and Mapping (ACSM)

ACSM first published its *Metric Practice Guide for Surveying and Mapping* in 1978. To date 20 states have adopted legislation to permit the use of the metric system as the basis for their state plane coordinate systems.

Associated Builders and Contractors (ABC)

ABC is using its national publications and training programs to inform and educate members about metric. During the past year, all ABC's publications have carried articles on metric. ABC's craft training manuals for electricians, millwrights, pipefitters, welders, carpenters, plumbers, sheet metal workers, metal building assemblers, and instrumentation control mechanics incorporate metric in their core curricula.

Institute of the Ironworking Industry (III)

III reports that the International Association of Bridge Structural and Ornamental Iron Workers recently published an apprentice and journeyman student guide, titled *Metrics for Ironworkers.*

Instrument Society of America (ISA)

ISA produces instrument and control systems standards for the HVAC and industrial process industries in the United States and abroad. All new and recently revised ISA standards express measurements in metric units.

International Concrete Repair Institute (ICRI)

ICRI regularly informs its members about the progress of construction metrication through its *Concrete Repair Bulletin* and uses metric units in its publications.

National Glass Association (NGA)

The glass industry is international and most NGA members work in metric now. Since the making of float glass is computer controlled, it can be produced in metric sizes and thickness.

National Stone Association (NSA)

NSA has concluded that there will be no significant impact on the stone industry. Stone products are typically specified by gradations determined through sieve analysis. Testing sieves are in metric sizes now with nominal inch-pound names provided for current use. Therefore the gradation of products will not change, just the units in the specifications. The industry's equipment suppliers are for the most part international and their equipment is predominantly metric. The only remaining task is the conversion of computer software used by quarry operators for weighing and invoicing trucks so their weights can be recorded in kilograms and metric tons.

North American Insulation Manufacturers Association (NAIMA)

Many NAIMA members have international operations and make metric products now.

Portland Cement Association (PCA)

PCA's metric policy states that all publications, videotapes, slide sets, and computer programs will be developed to include metric units. Metric has been added to most of PCA's recently updated publications and its concrete design computer programs have metric capability now.

SCOPE OF WORK
(EXAMPLE TAKEN FROM SOUTHWESTDIV)

The following statement is included in the scope of work for architect-engineering services:

"Metric Units of Measurement for design and construction will be required. See Paragraph 5.2.3 of the A-E Guide."

The following is the text of paragraph 5.2.3 of SOUTHWESTDIV's A-0E Guide:

5.2.3.3 METRIC REQUIREMENTS. When a project is required to be designed and built using metric units of measurement, the following shall apply:

a. All measurements and units shall be shown in SI metric units (SI: System International) exclusively. This includes but is not limited to: Linear measurements, area measurements, volumetric measurements, temperature measurements, climate requirements, waterflows, pressure requirements, noise requirements, lighting requirements, structural characteristics, electrical characteristics, plumbing characteristics, HVAC characteristics, equipment capacities, conveyance system ratings, and all power and energy units.

b. English system measurements shall not appear in reports, drawings, specifications, cost estimating, or any other submissions.

c. Design must take place using a 600 x 600 mm planning grid. The AE firm must strive to use as many "hard metric" products as possible, where competitively available. Where metric products are not available, soft conversion to metric is required, (e.g. 2" x 4") will read (2 x 25.4 = 50.8, = 50) x (4 x 25.4 = 116.0, = 100) 50 mm x 100 mm.

d. The latest edition of Metric Guide for Federal Construction shall be used as guidance on drawings, specifications and other elements of metric implementation. Additional guidance can be used that is published by the American Institute of Architects (AIA), Graphic Standards, "Eight Edition", ASTM E621 and ASTM E380.

e. All cost estimating shall be done in metric units only.

f. All terminology in the Specifications shall be in metric.

g. All correspondence must contain SI units exclusively.

h. All meeting presentations and discussions of measurements or units must be conducted using SI metric units.

I. Shop drawings, catalog cuts, and other submissions during the construction phase will be in metric units.

j. All Operation and Maintenance Manuals will be in metric units.

k. The one hundred percent submittal will include a report identifying all hard metric products specified.

SOUTHWESTDIV's A-E Guide contains the following definitions regarding hard and soft metric:

5.2.3.1 HARD METRIC. The term "hard metric" denotes the conversion of inch-pound units to new, rounded, easy-to-use metric measurements.

5.2.3.2 SOFT METRIC. The term "soft metric" denotes the mathematical conversion of inch-pound units to metric measurements with little or no rounding.

VII. APPENDIX D: PRODUCT RESOURCES

NAVFAC PRODUCT STARTER LIST

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PROPOSED METRIC PRODUCT STARTER LIST

OBJECTIVE FOR A METRIC PRODUCT STARTER LIST

This package was prepared for the purpose of simulating discussion on the possibility of developing a starter list of products with new metric sizes that are available, or will be available soon, for use in construction. If it is feasible to establish such a list, this it would give designers a minimum set of metric products to include in their designs and would eliminate the need for duplicative availability research. The starter list would also give contractors and suppliers a heads up on metric products that we will be requiring in our construction bid packages.

The following discussion of building products that will and will not change as we transition to a metric way of doing business is based on the "Metric in Construction" newsletter of May-June 1994.

PRODUCTS THAT CHANGE

Modular products--brick, drywall, plywood, suspended ceiling components, and raised floors. They will undergo "hard" conversion; that is, their dimensions will change to new rounded metric numbers to fit the universal 600 x 600 mm metric planning grid.

Industry initiatives will result in a number of other products such as concrete reinforcing bars and various kinds of fasteners being converted to new metric sizes.

Custom fabricated products (for example, cabinets, stairs, handrails, ductwork, commercial doors and windows, structural steel, and precast concrete) and poured-in-place concrete usually can be made in any size, inch-pound or metric, with equal ease; therefore, for metric jobs, they simply will be fabricated or formed in metric.

PRODUCTS THAT STAY THE SAME

The balance of products since they are cut-to-fit at the jobsite (for example, framing lumber, woodwork, wiring, piping, and roofing) **or are not dimensionally sensitive** (for example, fasteners, hardware, electrical components, plumbing fixtures, HVAC equipment and gravel). Such products will just be "soft" converted--that is relabeled in metric. A 2-3/4" x 4-1/2" wall switch face plated will be relabeled 70 x 115 mm and a 30 gallon tank, 114L. Manufactures may convert many of these products to new rounded metric sizes eventually but only when it becomes convenient for them to do so.

INITIAL METRIC PRODUCT STARTER LIST

The initial metric product list that follows is based on changing building products that represent dimensional compatibility of building assembly components. Multiple manufacturers are available according to GSA Region 3's "M2." Because of the nature of the products on the starter list, the list contains a group of products who's availability may be considered as regional and others which are national.

REGIONAL

04 CMU (BLOCK)
04 BRICK

NATIONAL

05 STEEL PLATE
05 STRUCTURAL BOLTS
06 PLYWOOD
07 INSULATION
08 DOORS, METAL OR WOOD
08 WINDOWS
09 CARPET
09 CEILING SYSTEMS
09 DRYWALL
09 FLOOR TILE
10 ACCESS FLOORS
14 ELEVATORS
15 AIR DIFFUSERS AND GRILLES (CEILING SYSTEMS)
16 LIGHTING FIXTURES

04 CMU (BLOCK)

What will change

~~Block sizes--tp 190 x 190 x 390 mm~~

Mortar joints from 1/2' tp 10„

Block module--from 2' x 2' to 600 x 600 mm

What will stay the same

Block and mortar composition

Note (from the "Metric in Construction" newsletter of September-October 1993):

The concrete masonry block industry has said it will have difficulty supplying block in hard metric sizes. This industry is composed primarily of small producers with a marketing radius of from 60 to 300 km. Hard metric conversion would require that they buy new mold boxes, which cost in the range of from $10,000 to $20,000 apiece-a large capital investment for small firms that have been hit by the economic downturn.

In response to these problems, the General Services Administration (GSA) has modified it Metric Design Guide (July 1993) to permit the use of either conventional inch-pound block or metric block. The Guide states:

Masonry walls have a critical wall thickness for fire resistance and compressive strength. Beyond this, it is not important that dimension the height and width of a masonry unit is except for appearance, the ability to accommodate metric windows and door openings, having even coursing for ties and round dimensions between openings for ease of builder measurement, and the weight of the unit for lifting. Project requirements should be limited to these factors with total competitive pricing determining the dimensioning.

Metric modular block is 190 by 190 by 390 mm. This equates to 7-1/2 by 7-1/2 by 15- 3/8 inches. Conventional (inch pound) modular block is 194 by 194 by 397 mm, quite similar to metric block.

04 BRICK

What will change

Standard brick--to 90 x 57 x 190mm

Mortar joints--from 3/8" and 1/2' to 10 mm

Brick module--from 2' x 2' to 600 x 600 mm.

What will stay the same

Brick and mortar composition

Of the 100 or so brick sizes currently made 5 to 10 are within a millimeter of a metric brick so the brick industry will have no trouble supplying metric brick

05 STEEL PLATE

05 STRUCTURAL BOLTS

What will change

Bolts--to metric diameters and threads per ASTM A325M and A490M

06 PLYWOOD

What will Change

Widths--from 4'-0" to 1200mm

Heights--from 8'-0" to 2400mm, 10'-0"to 3000 mm.

What will stay the same

Thicknesses, so fire, acoustic, and thermal ratings won't have to be recalculated.

Note:

Metric plywood is readily available but with a possible cost penalty for small orders.

07 INSULATION

BATT INSULATION

What will Change

Nominal width labels--from 16" to 16"/400 mm and 25" to 24"/600 mm.

What will stay the same

Everything else

Note:

Batts will not change in width; they'll just have a tighter "friction fit" when installed between metric-spaced framing members.

RIGID INSULATION

What will Change

Widths--from 4'-0" to 1200mm

Heights--from 8'-0" to 2400mm, 10'-0"to 3000 mm.

What will stay the same

Thicknesses, so fire, acoustic, and thermal ratings won't have to be recalculated.

Note:

Metric rigid insulation may not be available at this time.

08 DOORS, METAL OR WOOD

What will change

Height--from 6'-8" to 2050 mm or 2100 mm and from 7'-0" to 2100 mm

Width--from 2'6" to 750 mm, from 2'-8" to 800 mm, from 2'-10' to 850mm, from 3'-0" to 900 mm or 950 mm, and from 3'-4" to 1000 mm

What will stay the same

Door thicknesses

Door materials and hardware

Note:

For commercial work, doors can be ordered in any size since they normally are custom-fabricated

08 WINDOWS

09 CARPET

09 CEILING SYSTEMS

What will change

Grids and lay in ceiling tile, air diffusers, and lighting fixtures--from 2'x 2' tp 600 x 600 mm and from 2' x 4' to 600 x 1200 mm.

What will stay the same

Grid profiles, tile thicknesses, air diffuser capacities, florescent tubes, and means of suspension.

09 DRYWALL

What will Change

Widths--from 4'-0" to 1200mm

Heights--from 8'-0" to 2400mm, 10'-0"to 3000 mm.

What will stay the same

Thicknesses, so fire, acoustic, and thermal ratings won't have to be recalculated.

Note:

Metric drywall is readily available but with a possible cost penalty for small orders. .

09 FLOOR TILE

10 ACCESS FLOORS

What will change

Grids and lay-in floor tile--from 2' x 2' to 600 x 600 mm

What will stay the same

Grid profiles, tile thicknesses, and means of support

14 ELEVATORS

15 AIR DIFFUSERS AND GRILLES (CEILING SYSTEMS)

What will change

Grids and lay in ceiling tile, air diffusers, and lighting fixtures--from 2'x 2' tp 600 x 600 mm and from 2' x 4' to 600 x 1200 mm.

What will stay the same

Grid profiles, tile thicknesses, air diffuser capacities, florescent tubes, and means of suspension.

16 LIGHTING FIXTURES

What will change

Grids and lay in ceiling tile, air diffusers, and lighting fixtures--from 2'x 2' tp 600 x 600 mm and from 2' x 4' to 600 x 1200 mm.

What will stay the same

Grid profiles, tile thicknesses, air diffuser capacities, florescent tubes, and means of suspension.

VIII. REFERENCES

PACDIV METRIC GUIDE FOR CONTRACT DOCUMENT PREPARATION

REFERENCES

NOTE: THE FOLLOWING REFERENCED DOCULMENTS FORM A PART OF THE PACDIV METRIC GUIDE. USERS OF THIS GUIDE SHOULD REFER TO THE LATEST DOCUMENT REVISIONS.

GOVERNMENT PUBLICATIONS

FEDERAL ACQUISITION REGUALTIONS (FAR)

FAR 25.405(b)	North American Free Trade Agreement (NAFTA)

FEDERAL REGISTER

Vol. 55, No. 145	Presidential Documents: Metric Usage in Federal Government Programs
Vol. 61, No. 96	Department of Commerce: Federal Agency Guidance for the Acquisition of Modular Metric Construction Products (Cox Bill)

GENERAL SERVICES ADMINISTRATION (GSA)

PBS-PQ160	Metric Design Guide

MILITARY HANDBOOK (MILHDBK)

MIL-HDBK-1008	Fire Protection For Facilities

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST 811	Guide for The Use Of The International System of Units (SI)

NAVAL FACILITIES ENGINEERING COMMAND (NAVFAC)

NAVFAC	Metric Product Starter List
NAVFAC	NAVFAC Metrication Conversion Policy For Design, Planning and Design Criteria, and NAVFAC Guide Specifications

PACIFIC DIVISION NAVAL FACILITIES ENGINEERING COMMAND (PACDIV)

P-74	A-E Guide

NATIONAL INSTITUTE OF BUILDING SCIENCES (NIBS)

NIBS	Newsletter: Construction Metrication

CANADIAN GOVERNMENT PUBLICATIONS
DEPARTMENT OF FOREIGN AFFAIRS AND INTERNATIONAL TRADE

NAFTA	Canadian Directory of Metric Construction Products

NON-GOVERNMENT PUBLICATIONS

AMERICAN ASSOCIATION OF STATE HIGHWAY TRANSPORTATION OFFICIALS (AASHTO)

M31M	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 318	Building Code Requirements for Reinforced Concrete

AMERICAN INSTITUTE OF ARCHITECTS (AIA)

AIA	AIA Mastermetric, A Guide for Using The International System (SI) in Construction Documents

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-95	Minimum Design Loads for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B 1.20.1	Pipe Threads, General Purpose (Inch) Revision and Redesignation of ASME/ANSI B2.1-1968 R (1992)
ASME B 16.1	Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B 16.3	Malleable Iron Threaded Fittings Classes 150 and 300

AMERICAN SOCIETY OF TESTING MATERIALS (ASTM)

ASTM A 510M	General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel [Metric]
ASTM A 615	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement AASHTO No. M31M
ASTM B 3	Soft or Annealed Copper Wire

ASTM E 380	Standard Practice for Use of the International System of Units (SI) (The Modernize Metric Unit)
ASTM E 62	Standard Practice for Use of Metric (SI) Units in Building Design and Construction
IEEE/ASTM SI	Standard for Use of the International System of Units (SI): The Modern Metric System

AMERICAN WIRE GAGE (AWG)

AWG	(general reference on electrical wire gages)

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI	Metric Rebar Design and Detailing Data

COUNTY OF ORANGE CALIFORNIA

OC	Working In Metric: A Conversion Guide for Orange County

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO)

UBC	Uniform Building Code

R.S. MEANS COMPANY

RSM	How to Estimate With Metric Units

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

NEMA	(General electrical industry standards)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13	Standard for Installation of Fire Sprinklers
NFPA 70	National Electric Code (NEC)
NFPA 1- 2001	National Fire Code

U. S. METRIC ASSOCIATION (USMA)

USMA	Metric Vendor List
USMA	Newsletter: Metric Today